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EXAMPLES, CONCLUSIONS, AND MAXIMS

OF

MODERN NAVAL TACTICS,

BY

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PREFACE.

In placing these thoughts and remarks upon Naval Tactics before those who may be interested in the subject, I feel obliged to acknowledge a certain lack of experience, in a practical way, that must necessarily exist in a navy where an evolutionary fleet is not kept up.

Those nations which have always maintained large navies, and whose history and prestige date back to glorious pasts, have ever had great commanders and intelligent writers, who have made this branch of naval science a life-long study, both practically and theoretically. Upon the experience of these men, and from the writings of their naval editors, I have endeavored to give certain examples, deduce certain conclusions, and formulate certain maxims.

Naval Tactics means more than the handling of squadrons. It means the whole science of the conduct of vessels, whether they act singly or in concert; how to keep them together at sea; how to operate along a coast; how to conduct them through the inland waters of an enemy's country; how best to govern them in regard to any peculiar environment, whether of wind, weather, or adversary; whether to attack or to retreat, and, if the former, how best to employ their weapons of offense and defense.

The tactical integer is at all times changing according as the mechanical arts make prominent some one point in naval science, whether it be artillery or torpedoes, or the construction of the vessel itself. With wooden walls, broadside guns, and sails, it was the great fleet of many vessels. To-day, with the armor-clad and its all-round fire, torpedoes, and ram, it is the single ship.

Formerly the ship was a component of the fleet. To-day the fleet is a combination of ships.

Our own Navy has but marked its first century, yet its past history is filled with examples which teach startling and important lessons to the tacticians of older organizations.

During the war of 1812 a knowledge of this branch of naval science enabled us to add in nearly every equal encounter the name of the enemy's ship to our list of prizes.

The war of 1861 taught the lesson how to maintain the blockade of an enormous extent of coast, and the feasibility or riding out the heaviest gales of wind, anchored in the open sea, almost anywhere on available soundings. In this war too, was developed the tactics of the torpedo flotilla, likewise the passing of fortifications with vessels lashed together; also the carrying on of campaigns up the hardly navigable rivers of the enemy, with the peculiarities incident thereto.

With all the memories of the past clustering about us, we can only hope that the nation will once more seek to rehabilitate its marine defense. Should it do so, with our new ships there will be much for us to learn, and the following pages may serve to awaken an interest in a greatly neglected, yet very vital, subject.

ACKNOWLEDGMENT.

I wish to acknowledge my great indebtedness to the authors and naval authorities whose opinions, as set forth in the following works have been largely quoted and embodied:

Naval Tactics on the Open Sea with the Existing Types of Vessels and Weapons. By Captain the Hon. Edmund R. Fremantle, R. N.

The Gun, Ram, and Torpedo. By Commander Gerard H. U. Noel, R. N.

Essay on Naval Tactics. By Jno. Knox Laughton, M. A., naval instructor, R. N.

Steam Tactics in a General Action. By Lieut. Charles Campbell, R. N.

Études Comparatives de Tactique Navale. By Monsieur E. Farret, Lieutenant de Vaisseau, M. F.

Problems in Naval Tactics. By Vice-Admiral Randolph, R. N.

Éléments de Tactique Navale. By M. le Vice-Amiral Penhoat, M. F.

Remarks on the Maneuvers of Two Vessels in Action. By Lieut. G. R. Bethell, R. N.

Maritime Power and its Probable Application in War. By Capt. R. H. Harris, R. N.

La Guerre Maritime et les Ports Militaires de la France. By M. le Contre-Amiral Aube, M. F.

The Maneuvering Powers of Ships. By Capt. P. H. Colomb, R. N.

Essai sur la Tactique de Combat, et sur l'usage à faire des moyens d'Attaque et de Défense. By M. le Capitaine L. Rivet, M. F.

The British Navy, its Strength, Resources, and Administration. By Sir Thomas Brassey, K. C. B., M. P., M. A.

La Guerre d'Escadre et la Guerre de Côtes. By Monsieur P. Dislère.

Occasional Papers, Landing Parties, and Naval Brigade. By Lieut. T. B. M. Mason, U. S. N.

Étude sur les Combats de Mer. By M. Besson, Lieutenant de Vaisseau, M. F.

Attaque par les Torpilles et Défense à Opposer (Analysé de l'Anglais). By M. Fontaineau, M. F.

And to the many writers of articles published in home and foreign professional pamphlets.

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INTRODUCTION.

I.

Admiral Aube, in his most excellent treatise on "La Guerre Maritime et les Ports Militaires de la France," makes the following remark: "The object of all navies is war. The fundamental problem which devolves upon us, before all others, in our researches, is, "What will a naval war be?" Curious idea! No one at present, not even the most distinguished seaman, can answer this question."

It may seem strange that large navies are built up, and yet the requisite knowledge as to how ships can best be combined and employed together in warfare is wanting.

Nevertheless the tactician, either by studying theory or by means of such experience as in time of peace can be obtained, strives to answer the question, "How will modern ships fight at sea?"

II.

Naval Tactics is one of the most important branches of knowledge that can engage the attention of the naval officer, since it teaches how to apply in a fight the different arms which constitute the power of a naval vessel. These lessons are as numerous and as varied as are the ends in view to be attained in a maritime war.

Until actual experience in war decides otherwise the naval power of a country shows itself in its superior squadrons, that is to say, the reunion in number, more or less great, of war vessels of the most recent type.

To have a share in the great dominion of the sea a nation must enter the contest with a strong fleet, ready to fight; supplied with the most modern weapons, and with a well-disciplined and thoroughly intelligent corps of officers. It should be borne in mind that a war once begun, the naval power of a nation will hardly increase, since ships take so long to build. In fact its naval strength will steadily run down through withdrawal of vessels for repairs incident to service, from damage done by the enemy, and from inevitable losses.

One of the maxims of war, according to Captain Harris, of the British Navy, is that—

> Every unit of a mercantile fleet, with the exception of its fastest steamers, is a national weakness in maritime war, so also is every unfortified town on the seaboard.

Since this is the case, we can easily see how necessary an efficient, if not a large, navy is to a nation having a large carrying trade on the seas, and a proper jealousy of her rights; how vital it is to have the ships of this navy, through drill and by experience in squadron, ready at all times to prevent imposition on the part of unscrupulous powers who may choose to be aggressive. It is the part of Naval Tactics to teach this navy how best to serve this end.

III.

The modern ship is a complex engine of war. It contains, to be effective, a combination of all the offensive weapons that science can devise. To be complete it must be supplied with the best guns, great power of engine and facility of turning; greatest strength of hull, in order that its ram may be efficient; and in it must be installed the best method for discharging automobile torpedoes. For a ship to possess only one or two of these weapons of offense is to put herself at a decided disadvantage in regard to some other vessel, otherwise less commendable, possessed of all three. Perhaps, in order to equip ourselves with these weapons, we may have to buy in a foreign market, but to have complete ships we must have the best weapons. To use domestic inventions of less warlike value is to handicap ourselves in a fatally stupid manner.

In regard to the knowledge required for the management of these new vessels we can do best by quoting the words of Vice-Admiral Randolph, R. N.:

> The first step towards discovering a means to an end must be to define clearly what that end is, and the following is submitted as the desideratum in naval tactics:
>
> It will be considered that the vastly increased cost, size, power, and capabilities of the modern ship of war increases also the importance of its being ably and carefully handled.
>
> We may assume that the one supreme object of a ship of war, though not its only *raison d'être*, is to beat the enemy at sea. Superior seamanship, combined with superior gunnery, are the means.

From the words of a French writer we can gather when and how this knowledge is to be applied:

> A fight between ships of similar or different caliber or class, an engagement between squadrons, the pursuit of a weaker opponent, the retreat from a stronger foe, engagements against fortifications, such are at a glance the operations that a fleet may have to perform, and upon which Naval Tactics must enlighten us, not only by mathematical precepts, but by general information.
>
> In order to combine the evolutions of ships in such a manner as to draw out of these engines of war the greatest usefulness—that is to say, to cause the greatest injury to the enemy—it is necessary to establish certain rules. These measures intended to preserve the singleness of design, always different and often numerous, have in themselves but one end—they constitute *evolutions*.
>
> Evolutions are the means employed to move squadrons under ordinary circumstances at sea and to take fleets into action in the most advantageous manner. They form an important part of naval tactics, but do not constitute it entirely. Two nations may have the general principles of tactics in common, and the means of applying them, that is to say, the system of evolutions, different.

From the following, we see that Naval Tactics has to deal with a number of recognized conditions, from which may be derived certain *postulates.* These have been framed in the following language by Admiral Randolph:

1st. The maximum power of attack requires the freest possible use by each ship of its ram and artillery (torpedo included) without injury to friends.

2d. The utmost mutual support should be given by friends, and protection from hostile rams.

3d. The closest order consistent with due regard to safety to each other should be maintained in order to meet the preceding demand, and to avoid the danger of one ship being unnecessarily exposed to the fire of two or more of the enemy.

4th. Utmost freedom to each ship of increasing or reducing speed, as well as altering course, or hauling out of action, or for other sufficient cause, is highly desirable.

5th. Facility of passing quickly from one enemy to another, either after partial or effectual collision or unavoidable separation, is important.

6th. Facility for the reforming of separated ships for renewed attack, or mutual support after the first shock of battle, is of high value.

7th. When possible, two ships, or at least a decisive superiority of force, should be thrown upon one.

8th. A reserve should, when possible, be retained to consummate and secure the fruits of victory.

I cannot more fitly close this introduction than by quoting the language of Lieutenant Campbell, R. N., in his admirable paper on "Steam tactics in a general action."

I would urge in conclusion what an important place tactical maneuvers should take in our naval education. From the earliest period of his career, no officer can study too carefully the signal books and the system of large fleets and squadrons acting in unison.

CHAPTER I.

DEFINITIONS AND EXPLANATIONS.

I.

In regard to the value of certain terms used in connection with this work so much diversity of opinion exists, that it will be as well to define, as nearly as possible, the meaning intended to be conveyed.

Strategy.—Combinations made by the commander-in-chief of a force acting on different points over a large area, to compel or annul certain movements of the enemy, or to unite or separate portions of a large sea force. Strategy refers not to the conduct of a battle but of a campaign, and orders the locality in which the fleet is to cruise and the object which it is to have specially in view, such as the blockade of a port, raising a blockade, or simply the meeting with and engaging the enemy. It is the greater science, as including all those vast combinations which lead to the subsequent available displays of naval tactics.

Naval tactics has sometimes been misused in the sense of strategy, whereas in fact it is a subordinate division of this science, since it refers to the execution of the detailed plans of strategical objects. It is the art of disposing naval forces in order of battle, and performing evolutions in the face or vicinity of the enemy; also, of performing all the possible evolutions with ships, sections, groups, divisions, squadrons, or fleets when acting together; *i. e.*, in such order that they are controlled by general signal—the employment of all the offensive powers of a ship, artillery, rams, torpedoes, or any naval weapons. Naval tactics is sometimes improperly restricted to the absolute performance of evolutions and forming of orders.

II.

Formation or Order.—Any arrangement or combination of vessels, on a line of bearing, or on lines of bearing, designed for cruising, for attacking, or for retreat.

Evolutions.—The necessary movement or combination of movements by which a fleet, or lesser number of ships acting together, proceed from one formation to another. Evolutions in the case of a single ship are when she proceeds from one point to another to gain some tactical advantage.

Movement or Maneuver.—Action of the whole force, or any detached portion of it, moving in the presence of the main body by which a position of advantage is sought to be gained. A component part of an evolution.

Change of Course.—Bringing the ship's head in some other direction.

Change of Direction.—Altering the compass bearing of the line of bearing that the formation is already on.

Line of Bearing.—An imaginary straight line passing through the same point of all the ships in some formation. It is designated by its direction in regard to the points of the compass as, "On a line of bearing SE. - NW." Or if the signal came from the Admiral, he would designate the line by its bearing *from* the flag-ship; as, "Form on line of bearing SE."

Absolute Bearing.—The compass bearing of one ship from another; as, "Bearing of A from B, NW. by N."

Relative Bearing.—The bearing of one ship from another, expressed in regard to the ship itself; as, "A bears from B two points abaft the beam."

A *ship* can *change her course*, which for her is a *change of direction*, or can *move* or *maneuver* in such a manner as to perform an *evolution.*

A *section*, *group*, *division*, *squadron*, or *fleet* can *change course*, by each ship's head coming to some other common compass bearing; or by a *movement*, which is a *maneuver*, can *change direction* or the bearing of its *line of bearing*, which will produce the same or another *formation* on another *line of bearing.* Or when, in any *formation*, this assemblage of vessels, either by a *simultaneous*, *successive*, or *direct movement*, or by a *conversion*, or by a *wheel in concentric circles*, or by a combination of two or more of these, or by performing the same movement more than once, can execute *evolutions*, and so pass to some other *formation.*

If ships bear relatively right ahead and right astern of one another, they are in "*line ahead.*" If they bear right abeam of one another, they are in "*line abreast.*" If they bear bow and quartering from each other, they are "*in échelon.*" (See Plate I, Figs. 1, 2, 3, 4, 5.) These formations are termed *simple.*

If any combination of vessels divide and form on more than one line of bearing, it assumes a *compound* or *complex formation*, and is then said to be in "*line ahead in two columns*" or "*in double line ahead;*" "*in alternate line ahead;*" "*in line ahead in groups;*" "*in double line abreast;*" "*in alternate line abreast;*" *in groups in line abreast;*" "*in naval square;*" "*in double échelon;*" or "*in groups in double échelon.*" If when in double échelon the angle and the ships' heads lie in the same general direction, the fleet is in "*chase formation;*" when the angle and the ships' heads are in opposite directions, it is in "*retreat formation.*" (See Plates II & III.)

Alternate Lines are those where the ships in one line are opposite the spaces in the other. This formation is also known by the names of "*checkered lines*" and "*supplementary lines.*"

Naval Square is a formation of equal front and depth. The ships are so disposed that the distances and intervals are equal and the same in number.

Distance is the space between ships on the same line of bearing.

Interval is the perpendicular distance between two lines of bearing.

III.

THE TURNING CIRCLE.

(See Plate IV, Fig. 1.)

Octant.—A turn of 4 points, Pd^1, d^2, d^3, &c.

Final Circle.—The path a ship ultimately takes, assumed to be the circumference of a circle through the points reached at the end of the second, third, and fourth octants, as the arc d^2, d^3, d^4, of which C is the center.

Final Diameter and Radius.—The diameter and radius of the final circle.

Advance.—The distance traveled over at any point of the turn measured in a line parallel to the original course. Thus $f^1\ d^1$ is the advance at 4 points; $f^2\ d^2$ the advance at 8 points, and so on.

Transfer.—The distance traveled over at any point of the turn to the right or left of the prolongation of the original course, measured in a line at right angles to it. Thus, $e^3\ d^3$ is the transfer at 12 points, and $e^4\ a^4$ is the transfer at 16 points.

NOTE.—*The advance is the ordinate, and the transfer the abscissa of the curve at any point.*

Tactical Diameter is the transfer at 16 points, as $e^4\ d^4$, or the distance between the two courses when the original course is reversed.

Drift Angle is the angle included between the keel line of the ship and the tangent to the turning circle passing through the pivoting point of the ship. This drift angle is said to be the principal cause of the decrease of speed in turning, and the rudder pressure has little to do with it. Owing to the drift angle it is incorrect to assume that the ship has passed through a quarter, half, or whole circle when the ship's head has turned through 90°, 180°, or 360°, respectively.

Chord of so many points is the distance between the center of the middle line at the moment of moving the helm and its position when so many points have been turned. Thus, Pd^3 is the chord of 12 points. It is a convenient measure of turning powers so far as space is concerned.

Length is the length of the ship between perpendiculars. It is sometimes used to compare the space-measures of different ships' turning powers. Thus, the advance is so many *lengths;* the transfer so many; the chord so many, and so on. When one ship shows a greater number of *lengths* than another in any of these magnitudes, she has so much worse turning powers, so far as space is concerned.

Time-Length is the time it takes a ship to pass over her own length. It is necessarily varied with the speed, but it is a useful time measure for comparing the turning powers of any two ships. Thus, a ship is said to turn 4, 8, 12, or 16 points in so many *time-lengths*, and if another ship is shown to take more *time-lengths* to make the same turn, she has worse maneuvering power, so far as time is concerned.

Kick is the irregularity of the path of the ship observable when the helm is put down in turning. It is caused by the stern tending to swing out at right angles with the course when the rudder force begins to act. (See Plate IV, Fig. 2.)

Heeling Angle is due chiefly to centrifugal force, and varies—

1. Directly as the square of the speed of the ship.
2. Inversely with the metacentric height.
3. Inversely with the radius of the circle.

CHAPTER II.

WAR VESSELS.

I.

It comes within our province to consider only the war vessel in its connection with naval tactics. That is to say, to meet the enemy on the open sea we must oppose him with a fleet at least equal to his own in number, construction, speed, and offensive power. To protect our coasts we must be supplied with proper vessels, which can keep the sea, yet be of sufficiently light draft to enter most of our harbors. They must be protected in their construction against the projectiles of the armored fleet of the enemy, and they must possess weapons of offense and defense of the most commendable pattern.

To assist these fleets we need protected vessels of large size, termed cruisers; also a smaller class of the same name, corvettes, and gun-vessels. These should all be of great speed, have batteries of great penetration, and be fitted with automobile torpedoes. They should be of such heavy construction and possess such facility of turning as to be efficient rams against unarmored vessels.

Torpedo vessels of different sizes, armed with automobile torpedoes, machine guns, and possessed of great speed, are pre-eminently war vessels, but not of the line of battle.

A great diversity of opinion exists as to what kind of a vessel shall be entitled to this place in an engagement, but we think that a list of standard qualifications would be something like the following, suggested by Mr. Campbell:

1st. Great speed and coal-carrying power.
2d. Armor protection; unsinkability.
3d. Quickness in turning.
4th. Ability to keep the sea in all weathers.
5th. Capacity for stowing a large supply of provisions.
6th. A heavy armament of guns of the greatest penetrating power.

To these should be added a—

7th. Installation of the automobile torpedo.

Each ship of the line is a unit. She should therefore combine in herself all the elements of offense and defense. Her speed should be great, her turning power good, and in order to possess this quality, her helm should be moved by steam or by hydraulic power. She should be protected by sufficient and properly-distributed armor. She should be built with a ram bow, and be divided into numerous water-tight compartments. Her battery should consist of a few heavy guns, several lighter ones, a number of mechanical guns, also automobile torpedoes. As spar and divergent torpedoes are necessary at times, she should be fitted for them. Among her boats should be two torpedo launches, handy and of high speed. They should be as unsinkable as possible, and be well armed with torpedoes and machine guns.

It is not to be supposed that each line-of-battle ship will combine all these qualities, but the most eminent will decide her tactical value and will assign to her a proper place in the line. In fact we know, nowadays, that a fleet of vessels of the same size, build, and battery would be hardly possible, but each ship will have her value either for ram, artillery, or torpedo.

II.

Probably the most formidable line-of-battle ship is the sea-going armor-clad. She should combine the maximum of aggressive power with the maximum of resisting qualities.

The functions of the sea-going armored fleet would be to attack in line of battle the enemy's fleet wherever found; to drive it from our shores; to follow it, and confine it to its own harbors; to maintain an unchallenged command of the sea routes leading to our coasts; to protect our harbors against the enemy's fleet, and to oppose all attempts under cover of the enemy's fleet of the landing of troops for invasion at any point of the coast.

III.

Comparing the merits of the armor-clad with the merits of the protected or unarmored vessel for position in the line of battle, Admiral Sir Geoffrey Hornby, K. C. B., uses the following argument in favor of the armored vessel:

> You may put an iron-clad in any position you please, and if she is attacked by three of these unarmored vessels she will make a run at one vessel or the other, attack her with her guns, and threaten her with her ram, and it must be death to that vessel if she touches her any way. The two other vessels, you say, will follow and disturb the action of the iron-clad; but it must be recollected that the iron-clad will always be firing at them, one gun at least, and with shells, the bursting power of which must necessarily, as far as we know, destroy the fighting power of the cruiser. If any one contemplates what the bursting of a shell filled with 37 pounds of powder in the center of any unarmored vessel would be, I think he will agree there would be no more fight left in the ship. It is no answer to say that the ship is armed with a gun as heavy as the iron-clad has; the *morale* of the people will be destroyed, and they will be unable to continue the action against the concentrated force to which they are opposed. For that reason I hold that the unarmored ship cannot contend against the armored.

To cite a contrary opinion, we give that of Sir William G. Armstrong, C. B., F. R. S., expressed in these words:

> Not only did we see that armor was unavailing against torpedo attack and ram-

ming, but we were justified in concluding that every attempt to increase resistance to projectiles would be quickly followed by a corresponding increase in the power of artillery.

As to the comparative liability of an iron-clad and an unarmored ship to be sunk by projectiles, there was much less difference between them than was generally supposed; because the unarmored ship, though freely penetrable, might be so constructed that the entrance of water by perforation would not extensively flood the ship, unless it took place at a great number of critical places. Indeed, by introducing an under-water deck with divisional spaces, and by the partial application of cork, as in the Inflexible, for displacing influent water and thereby preserving stability, and also by a proper distribution of coal for the same purpose, an unarmored ship might be rendered almost incapable of being sunk; and it was rather surprising that so little attention had been directed to the attainment of that object. It was not too much to say that for the cost of one iron-clad we could have three unarmored ships of far higher speed and carrying collectively three armaments, each equal to that of the armored vessel.

It might be asked, which would be the better investment? If it were imagined that the three were matched in combat against the one, it would be perceived that, in addition to their numerical superiority, the former would possess many advantages. Being smaller, they would be more difficult to hit. Being swifter, they could choose their positions, and be free to attack or retreat at pleasure. Being more nimble in turning, they would be better adapted both for ramming and for evading the ram of their adversary. Finally, the conditions of superior speed and agility would favor their use of torpedoes and submarine projectiles.

It might, perhaps, be rash entirely to abandon armor so long as other nations continued to use it, because nothing but the experience of an actual war would remove all question as to its possible utility; but considering the indisputable value of a numerous fleet of swift and powerfully-armed ships, built with a view of obtaining the maximum amount of unarmored defense, and considering that such vessels, unlike armor-clads, could never grow much out of date, it did seem to be expedient that the chief expenditure should be upon ships of that description. Lightness should be the special aim in the construction of such vessels. Steel plates should be used for the hulls, and guns and engines should be of the least possible weight consistent with the necessary power. Every ton of weight saved would enable higher speed to be attained, and there was probably no quality in a fighting ship which would so much develop in importance as that of swiftness.

The question, notwithstanding the opinions of these eminent men, may still be considered as open. It cannot yet be said that it is decided whether an armor-clad, fit for the line of battle, is able to cope with a ram, armed with one gun of great power and caliber, and, say, four torpedo-vessels attacking simultaneously; all these vessels being supposed to have greater speed than the armor-clad. Experience alone will teach this lesson, but the maxim can be set down that if the question of money is put aside, in a contest between two vessels equal in offensive equipment and tactical qualities, the one with the strongest, most invulnerable hull will be the victor.

IV.

Cruising will be the most efficient way to ruin the enemy's commerce. It is therefore necessary to build a number of special cruisers. These vessels must have great speed and great coal-carrying capacity. Mr.

J. D'A. Samuda, at a meeting of the Institution of Naval Architects, had the following to say in reference to this class of vessel:

> Cruisers will be specially adapted and properly employed in protecting and convoying commerce, keeping open the seas to enable merchantmen to trade without interruption between the principal ports, lending naval assistance when needed, and performing many similar secondary services; and it may be freely admitted a very large number of them are required for such services, but they will be wholly unfitted to fight in line of battle and stand up against an armor-clad fleet, where endurance alone will determine the result of the encounter, and where the endurance of the iron-clad fleet may be reckoned by hours against minutes on the part of the unarmored cruisers, even if they elected to oppose the fighting fleet at all, for really, beyond possessing great value for guerrilla warfare, no decisive victory could be obtained or even hoped for against an iron-clad fleet by vessels whose safety, when hard pressed, would only be secured by their running away.

For a description of an efficient class of vessel of the type under consideration we read that—

> Light unarmored ships, designed by Mr. George Rendel, have lately been built in this country for foreign powers which with a displacement of only 1,300 tons had attained a speed of 16 knots an hour. They carried coal for steaming 4,000 miles and have already actually steamed 3,500 miles without replenishing. They were each armed with two 10-inch new-type guns, which had nearly an all-round fire, and were capable of piercing 18 inches of iron armor; and with four 40-pounders on the broadsides.

We will notice that Mr. Samuda does not contemplate putting cruisers in the line of battle, but his opinion is not sustained by that of Vice-Admiral Penhoat, of the French Navy, who thinks that these vessels should be built so staunchly, and be so well armed, as to qualify for this position in action. The Admiral believes that they could serve the fleet better by being placed in the line than by confining their operations to acting together as a lookout squadron, or as a reserve to tow disabled vessels out of action.

Of the smaller war vessels it will hardly be possible to enumerate all their duties. Corvettes must be the eyes of the armored fleet; they must drive off the cruisers of the enemy; they must unceasingly pursue and capture the merchant marine of the opposing nation. Where the lines of ocean commerce come together there must be the corvette to protect and to destroy.

To be worth anything small vessels should have good speed and coal-carrying power. If they are without these qualities, they should act with the coastwise fleet, or as tenders, or as flag-ships for the torpedo flotillas.

Altered merchant steamers become a class of coal and ammunition supply vessels, large torpedo-boat carriers, and commerce destroyers.

V.

Captain Noel, R. N., in common with a good many others, does not believe that the gun is the most important weapon of the fleet, while quite a number of writers agree with Mr. Laughton, who is of a contrary opinion, and says:

> The gun must still be held to be primarily the armament of ships, though secondarily the ram must enter largely into any scheme of battle.

All vessels, with perhaps the exception of the "Boston" class, are so designed that their bow-fire is stronger than their stern-fire. If the vessels of this class turn out to be all that is promised for them, we will perhaps be able to come nearer a solution of some of the vexed problems as regards defense of single vessels in action. It may be, though, that this class of vessel has a large gun installed in a position of least efficiency.

As regards the sizes of guns to be carried by vessels, whose calling is on the open sea, Admiral Penhoat does not believe that their artillery should be of large caliber, as the weight of the projectiles to be carried reduces their number in a great degree. Vessels will naturally come together in a fight, and artillery practice will be at short range. Large guns will come in for bombardments where the supply of ammunition can be kept up.

This question of ammunition supply is a very burning one, and has become a prominent problem in naval strategy and bears strongly upon tactics.

The weight of opinion is that the ram is the most formidable of a ship's offensive powers. Many authorities believe that it will be used as the ordinary fighting weapon, and that all methods and plans of attack should be based upon its employment; others think that it will probably only be used like the bayonet of the infantry soldier to give the *coup de grâce.* The reason for this being that it is so hard to maneuver a vessel to ram effectively where the target is animated by a spirit as active and as intelligent as your own. Official records of trials in Germany show this; and more than one writer is of the opinion that there must be some accidental disadvantage to allow a vessel to be rammed.

A vessel built for a ram *pur et simple,* to be unarmed in regard to battery, once so favorably looked upon by naval economists, seems to be losing its prestige as a fighting factor, since you pin your faith on one weapon. If your engines happen to break down you are at the mercy of the enemy.

Vessels designed to act as rams should be very handy, and therefore not large. Since they are pre-eminently of the line of battle, they should be armored or at least well protected.

It may be set down as a maxim that machine guns will play a prominent part in future naval combats. Every ship should have machine guns for the destruction of torpedo-boats close alongside.

Musketry and mechanical gun fire from on deck and aloft will be most useful. Not only do the decks offer a field for destruction, but the open gun-ports give entrance to the battery, into which your heavier projectiles may fail to penetrate.

All authorities are agreed that ships will fight at great speed; they will come close to one another on a charge and then separate, turn and charge again; therefore, the time through which small-arm fire can act and be useful is very short. The crew should be trained sharpshooters, being armed with rifles distinguished for rapidity and accuracy of fire rather than for length of range. Boarding will seldom or never be resorted to.

In an action the smaller guns of the battery, as well as the machine-guns, should fire at the enemy's upper deck and lightly-protected portions.

So much progress has been made in foreign navies with the automobile torpedo, that it is considered a perfectly reliable weapon within 400 yards, and that any nearer approach than this of the enemy makes it an extremely hazardous undertaking for him. In fact, the risk is so very great that, in the opinion of a German writer, ramming will hardly be attempted against any but defenseless ships. It may be mentioned here that the French, in addition to the automobile torpedo, are now using *divergent torpedoes*, which are towing-torpedoes, with a short scope of line.

VI.

It has been proposed to classify torpedo-steamers as follows:

To a class capable of operating outside of harbors, and of keeping the sea in bad weather, but generally to be carried by a special vessel, the name of *torpedo-vessels.*

The next smaller size to be used in harbor defense, and which will not accompany the fleet, the name of *torpedo boat.*

And, for the smallest class, such as are fitted to be carried by cruising vessels, the name of *torpedo-launches* or *torpedo-pinnaces.*

Lieutenant Campbell does not believe that line-of-battle ships should be fitted to carry torpedoes; but that they should have two "torpedo cutters," that they can always lower and use either aggressively or for defense. They should be capable of good speed, and be lowered ready for action when up with the enemy.

However, with all the varying phases of wind and weather on the open sea, it is hard to conceive how a line-of-battle ship can carry torpedo-boats large enough to be of service in an engagement. It will be difficult to lower them, and, if they have to be towed, it will interfere with the movements of the fleet, and they will at all times be liable to be swamped. They carry so little coal and provisions that they will need filling up very often, which will be difficult to do. Torpedo-boats of this kind are veritable *impedimenta* to the fleet, especially when, having lowered them, the fleet is obliged to defend them in retreat.

But, if they have these drawbacks, they should still be carried by ships of the line, as their utility in fleets will not be the less for defending ships at anchor, in acting as "lookouts," and to fight, if necessary.

The typical sea torpedo boat is a sea-going cruiser, able to carry its own crew, provisions, and coals. She should be a vessel of from 200 to 400 tons displacement, and should have immense speed and great turning power. There should be two to each ship of the line of battle, and they should cruise close to them. They should render offensive and defensive succor at all times, and might be used to tow out of action any disabled vessel. They should also keep an eye on the smaller torpedo-boats.

The most modern idea is that there should be a special vessel not of the line of battle, which should accompany a fleet, and which should be fitted to carry as many as possible of the largest-sized torpedo-vessels. She should be able to get her boats out and lower them, or pick them up, in the open sea.

The Italians have lately brought to notice a vessel of war, about 150 feet long, displacing 600 tons, and capable of making 25 knots. She is protected; almost, if not quite, unsinkable, and has excellent turning power, being fitted with two screws. Her weapons are the ram, two light guns forward, a heavy gun aft with great sweep of fire, and three decks of machine guns, about forty-five in all, which admit of fire in all necessary directions. There are two or more tubes for discharging automobile torpedoes. She is designed as a torpedo-boat destroyer, and is probably intended to accompany and act with the fleet.

CHAPTER III.

THE SHIP AND HER CAPTAIN.

I.

To command a modern vessel of war, the captain is called upon to post himself on points that formerly could, very properly, be left to his subordinates. Now he commands more than a *ship ;* he is in supreme charge of a missile, which is projected by power within itself. This missile, instead of moving in the medium of air, moves in air and water, both elements influencing its trajectory. It acts either as a *shot*, and rams an opponent, or like a *shell*, extending its destructive influence outside the confines of figure by means of guns or torpedoes.

The commander should thoroughly understand that he must, as the soul of this huge machine, comprehend fully all the complex results of invention which science, working through the mechanical arts, has accomplished, enabling him to transmit his scheme of action to the ponderous mass beneath him. His ship has her strong points and her weak ones. How to keep his mail between himself and the enemy, how, in case of extensive penetration, to save his ship, are points demanding his constant study.

What does the command of the modern ship in action require further, for the proper employment of the ram and torpedo? Let three eminent authorities speak.

Admiral the Count de Gueydon says:

> Above all, *steady nerves*, an accurate eye, and a sure hand. Science cannot develop these qualities; practice alone can.

Admiral Bourgois remarks:

> There is nothing like quick judgment and *sangfroid*. In action, captains must expect to have their designs frustrated by smoke from funnels and guns. The ordinary fleet maneuvers are in no way capable of teaching a captain his duty; this must come from drill against properly-constructed targets.

Admiral Jurien de la Gravière has described in graphic language the sort of training which is necessary in order to prepare officers for the rapid and desperate maneuvers of a battle with the ram. He remarks that after the first charge has taken place on both sides, the fight can only be renewed by the fleets turning and charging again. This turning will be the cause of innumerable fatal collisions between ships of the same side, unless the captains are thoroughly drilled. They must not only know tactics theoretically, but they must be perfectly certain of their ships, know what they are capable of, and, in case of breaking down or other accident, how to act to keep them out of the way of friendly vessels, and how best to present them to the enemy to offset their crippled condition. This experience cannot be obtained in the class-room or in small vessels. To be successful, the nerve of the captain must grow with his experience, and this condition of affairs can only be brought about by drilling in fleet tactics in line-of-battle ships, where collision means fatal damage, or by exercising at night in close order.

Unquestionably *nerve* is to be obtained only by actual experience, and unfortunately the use of large vessels for purposes of drill is expensive. If, however, this quality is *necessary*, our officers must be given the chance of actual practice, or they will fall behind those of other navies who have had it. Without preliminary exercise it is impossible to acquire that skill and precision in maneuvering which will be necessary for the conduct and safety of the ship or the fleet in the day of battle.

II.

The duty of the captain does not end with his own vessel; each captain, to be successful, must be thoroughly versed in naval tactics, which is now of more importance than ever before.

The Signal Book must be his constant study. Plans of actions must therein be laid down, and their minutest details committed to memory. A wrong turn, a slacking of the speed in time of battle, may mean confusion, if not destruction, to the fleet, as may also the rendering of inefficient support, through ignorance or inexperience, to one's neighbor.

III.

Captain the honorable Edmund R. Fremantle, R. N., asks the question :

> How many naval officers care to know the number of degrees of helm that can be given to their ships; the tending of the screw to turn the ship unassisted by the rudder; the effect of turning the engines astern when the ship has head or stern way; the result of increasing or reducing speed on the circle described in turning; what the nature of the so-called circle is; what the reduction of speed by putting the helm hard over; what heel a helm hard over may be expected to give the ship; what the drift angle means; what is the time of completing a circle at different speeds and its diameter?

Yet all these things must be known and more too. When the vessel leaves the dockyard she develops a strategical and tactical character requiring perhaps unlooked-for care, study, and watchfulness on the part of the captain. He must know how much coal is used at the different speeds and under different conditions of environment; what is the most economical expenditure of coal for speed developed. The working of the helm; can it be moved from side to side as rapidly as it should be to obtain the best results? Her easiness at sea; to what extent is she influenced by it in her rolling and pitching? Are her guns capable of use at all times, and can concentration of fire be quickly effected, &c.?

It would take too much space and be unnecessary, we think, to enter into details concerning the internal offensive and defensive economy of the ship, but it all bears upon naval tactics, and demands deep thought on the part of the commander.

After her speed has been established, and after the "Speed Table" has been filled out, comes in the determination of the ship's turning qualities. Experiments must be made under all circumstances called for in the "Helm Table," in which should be all the points bearing on fleet evolutions. Captain Noel, R. N., sums up these requirements, as follows:

1st. Speed at various revolutions of the engines.

2d. Everything in connection with the ship's turning qualities, including backing with and without the helm.

3d. Time required to bring the vessel to a state of rest by stopping and reversing the engines. This to be known for different speeds.

4th. The amount of helm required to turn at a certain standard speed on a certain standard arc.

Then as to the *sheering* of the ship (it is most important to be posted on this point); with a certain helm-angle and a certain speed, to find out the exact instant when to use the wheel in order to pass over a certain spot. Then again, as regards the engines, the captain must know what they are capable of doing under great stress; the amount of power that can be developed in going ahead or astern, and the length of time that it can be kept up.

The captain should see that his subordinates likely to succeed him in a fight are also fully informed on all these points.

A new element is the electric light. The best place for its installation on board ship is a question; where to put it so that the glare will least interfere with the observer. Officers will have much to learn concerning the judging of distances and the recognition of objects when this light furnishes the means of illumination.

After the captain has become familiar with his ship, his command must be associated with another vessel, and the two captains must be thoroughly drilled in their duties of mutual support. Upon the interdependence of vessels hangs the chances of victory. This section-drill should be had under all conditions of wind, weather, and speed. By it alone can the captain hope to take his place in the line of battle with any feeling of security.

IV.

We come now to consider the commanding officer's duty in action. The most eminent question is, what is the proper target for the ship? Is it the enemy's armor or the boilers and engines or the people on board? We should strive to deprive the enemy of his most important war factor, and we believe this to be the crew and officers. Knowing the ship, we should fire into the least protected part where the men are congregated, concentrating, of course, as many guns as possible upon her. We should remember that a ship lying still is not necessarily deprived of the use of *all* her weapons, so that disabling the machinery is of less value than killing the crew. The general rule to fire at the funnels is worthless. Not only should the captain and his officers be thoroughly conversant with the construction, as regards vulnerability, of the enemy's vessels, but this knowledge should extend to the leading seamen of the ship's company.

Another question arises: Is the *capture* of the vessel the principal object of the fight? From the opinions advanced by the leading naval minds we answer in the negative. Rams and torpedoes are used with but one view—the total destruction of the ship. If by killing the ship's company we reduce the enemy to a harmless state, we should, of course, take him as a prize; but the rule is to *sink* and *destroy*.

In order to use fore-and-aft fire in chase or retreat, or to know at any time the distance of the enemy, some quick method must be used to measure the interval separating ships, as nowadays such great speed is kept up, and a table of mast-head angles is too slow and too uncertain a method to furnish the necessary information. Too uncertain from the fact that some vessels are not sparred, and if they are sparred, the housing of light masts destroys the efficiency of the tables. Buckner's method is probably the best, or the distance should be determined by some kind of telemeter.

It may sometimes come within the experience of a captain to determine whether or not he should refuse combat. His action will be more or less governed by the following considerations, especially if the vessel is a great distance from home:

1st. Are the means at hand for repairing and for refitting safe and sufficient?

2d. Do not the interests of our specific work demand our not running the risk of getting crippled, and thus hinder us from keeping the sea?

There are two opinions, each directly opposed to the other and each covering the ground pretty well, bearing on the subject of the protection of the captain in action.

One side is represented by the writer of an article in the German Naval Official Publication. His opinion seems to be based on the results obtained lately in the German evolutionary squadron. The author is strongly opposed to proof-protections for the commanding officer. The captain is, in his opinion, in no greater danger *now* than he was a hundred years ago; but the fighting is livelier, and the methods of conducting a battle are more varied. If the captain is hidden he cannot see and control his ship. With smoke obscuring the fight, with guns above and rams and torpedoes below the water-line, he must be everywhere at the same time, otherwise in the confusion of battle he cannot be properly prepared to meet the dangers which beset him. To confine him at this time to a shelter is to circumscribe his view, as upon his sight, his actions depend and his judgment is governed.

On the other hand, M. Dislère in his work entitled "La Guerre d'Escadre et la Guerre de Côtes," takes exactly the opposite stand. He urges most strongly protection for the captain. It may be observed that Mr. Dislère represents the opinion of the larger number of writers upon this subject when he says:

> The captain must be protected against small-arm and shell fire for two reasons:
>
> First. Because it is necessary to put into the hands of the captain the steering of the ship, or at least under his direct supervision should be the person stationed to steer the ship. It is necessary then to have a fighting wheel on the bridge; and, if so, it must be protected.
>
> Secondly. It is difficult to replace the commanding officer during a fight.

There is still another reason for protecting the captain. If he falls during the performance of an evolution, no one, not even the officer by his side, can continue the train of thought and action to any profitable conclusion, or follow the first impulse of this instant. and upon which may depend the success of the fight.

CHAPTER IV.

EVOLUTIONS OF THE SHIP.

I.

In the last chapter we said that the following must be known of the ship:

1. Speed at different number of revolutions of the engines.
2. Turning power at different speeds.
3. Helm angle required to turn on a certain arc at a certain speed.

We will proceed now to discuss in detail the methods by which all these *data* may be obtained.

To use the different arms effectively requires one of these qualities to be more prominent than the others; for instance, in the opinion of many, turning power may be looked upon as the most important for a ship when used as a ram or to discharge torpedoes; whereas, for general work, speed is the most desirable quality.

For the use of artillery we need steadiness of platform, besides the evolutionary qualities under consideration. But this hardly comes within the province of tactics, belonging more properly to the naval architect.

II.

The reason that a ship in turning does not describe a circle is due to the fact that when the helm is put over she is moving in a straight line, which her momentum seeks to continue. It is only by degrees that she yields to the rudder, and then she is always some time behind it. The quicker that the helm can be put over the quicker will the vessel respond, and also more rapidly will the diameter of the turning circle decrease, and the time, if the helm angle can be increased up to 40° or more. We must have great angular movement for rudders and their connections, and quick-acting power immediately available to move the helm.

The radius of the turning circle for ordinarily large vessels is about 300 yards with a working speed of 8 knots.

Seamen generally agree that all single-screw steamers turn more quickly to one side than to the other under similar helm angles, and it is important to the naval officer to ascertain his ship's qualities in this respect. The rule is that the bow turns towards that side to which the descending blade of the screw falls. Thus a ship with a left-handed screw turns to port, or must be steered with port helm to keep her on her course. With ships of light draught it is said the contrary is the case.

Prof. Osborne Reynolds states that the distance required to bring a screw steamer to rest from full speed ahead, by the reversal of her engines, is independent, or nearly so, of the power of the engines, but depends on the size and build of the ship, and is generally between four and six times the ship's length.

III.

The two subjoined tables must now be filled out by every ship which expects to drill with the fleet, or to take her place in the line of battle. The "speed-table" takes cognizance of the speed of the ship for the different number of revolutions, and under different circumstances of wind and sea. The "helm-table" is a record of the ship's *advance* and *transfer*, also the *time* it takes the ship to turn through 45°, 90°, 135°, and 180°, under all conditions of wind and sea, and whether the turn is made toward or away from the wind. There must be a helm-table made out for each speed, say three speeds, which may be denominated "full," "fast," and "slow."

The speed-table is intended for ships steaming in squadron. To use it, we must have one filled out for every vessel associated with us. Suppose the leader of a line ahead makes a certain speed with 70 revolutions with sea rough, wind abeam, with a force of 4. Some other ship, in order to keep her place in the formation, in other words to make the leader's speed, can by reference to the leader's and her own table, having received the leader's signal as to the number of revolutions he is making, see that she need, under these circumstances, make only 60 revolutions.

So with the helm-table, every ship must have her own and her associates' for each speed. We are steaming in line ahead, and the signal is made to change direction 8 points to port, the sea being rough, the turn being made towards the wind, its force being 6. Turning to the table for this particular speed of the ship with the largest tactical diameter, and knowing that she will use 40° helm angle, we find a certain number of yards "advance," a certain number of yards "transfer," and a certain number of minutes for "time." Turning now to our own table for this same speed we see that the nearest figures under the same circumstances give us a helm angle of 35°. We therefore use this and find we keep our station and fulfill the required conditions.

FORM OF SPEED-TABLE.

Number of revolutions.	State of the sea.	Wind.																	
		Ahead.						Abeam.						Aft.					
		Force.						Force.						Force.					
		1.		4.		7.		1.		4.		7.		1.		4.		7.	
		K.	F.	K.	F.	K.	F.	K.	F.	K.	F.	K.	F.	K.	F.	K.	F.	K.	F.
75	Smooth																		
	Rough																		
	Very rough																		
70	Smooth																		
	Rough																		
	Very rough																		
65	Smooth																		
	Rough																		
	Very rough																		
60	Smooth																		
	Rough																		
	Very rough																		
55	Smooth																		
	Rough																		
	Very rough																		
50	Smooth																		
	Rough																		
	Very rough																		
45	Smooth																		
	Rough																		
	Very rough																		
40	Smooth																		
	Rough																		
	Very rough																		
35	Smooth																		
	Rough																		
	Very rough																		

FORM OF HELM-TABLE.

[One for each speed.]

Helm angle.	Turning as to wind.	Direction of turn.	Force of wind.	Advance.												Transfer.												Time.											
				45°.			90°.			135°.			180°.			45°.			90°.			135°.			180°.			45°.			90°.			135°.			180°.		
				Smooth.	Rough.	Very rough.	Smooth.	Rough.	Very rough.	Smooth.	Rough.	Very rough.	Smooth.	Rough.	Very rough.	Smooth.	Rough.	Very rough.	Smooth.	Rough.	Very rough.	Smooth.	Rough.	Very rough.	Smooth.	Rough.	Very rough.	Smooth.	Rough.	Very rough.	Smooth.	Rough.	Very rough.	Smooth.	Rough.	Very rough.	Smooth.	Rough.	Very rough.
Hard over	Towards	Starboard	0 to 4																																				
			4 to 8																																				
		Port	0 to 4																																				
			4 to 8																																				
	From	Starboard	0 to 4																																				
			4 to 8																																				
		Port	0 to 4																																				
			4 to 8																																				
40°	Towards	Starboard	0 to 4																																				
			4 to 8																																				
		Port	0 to 4																																				
			4 to 8																																				
	From	Starboard	0 to 4																																				
			4 to 8																																				
		Port	0 to 4																																				
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It is of the utmost importance that all the elements of the turning-circle should be known. There are many methods of finding them, but we will confine ourselves to those of Captain Colomb and of Mr. White, R. N.

In Captain Colomb's experiments with the Thunderer all the elements can be derived if the discussion is carried through a whole turn, or 32 points.

Some of the qualities of the turning circle bear more on naval tactics than do others, for instance, the *advance* and *transfer* are of the highest importance, especially to a ram; they should be known, however, for every ship. The determination of *tactical diameter* is also imperative.

The *loss of speed* in turning through a whole circle may be assumed at three times the length of the vessel.

A vessel with two screws, if she goes ahead on one and backs on the other, describes a spiral which constantly diminishes until its diameter becomes nothing, when its motion of translation ceases. If this vessel went ahead on one screw and stopped the other she would describe a turn of less diameter than if she went ahead on both screws and used her helm hard over.

The curve, which a ship with a single screw makes in turning, has generally been set down as a circle, and when the helm is righted she is supposed to start off on a tangent to this circle. As we have before stated, this is not so. Although the assumption may answer for the ordinary purposes of fleet drill, it would prove wofully inaccurate in fighting with the ram. The question then is, what curve does the ship make? On this point we trust the authorities we quote will enlighten us.

IV.

Captain Colomb, R. N., in discussing the turning-circles of vessels expresses substantially the following ideas as the result of his experience:

The maneuvering powers of ships comprise their powers of turning and of losing and gathering way. The measures of these powers are always twofold, *time* and *space.*

The time and space measurements of turning powers are much more numerous than those of losing and gathering way; but we are not masters of the maneuvering power of any ship until we know both and the principles which govern them.

We now take up the analysis of a single turning experiment to see what principles govern it.

Plate IV, Fig. 1, shows the trace of the curve made by a vessel in turning. The curve is drawn differently from what has been usual in the first part of the turn. When the trace is assumed to be that of the center of gravity, near the middle point of the ship, it has been usual to show the arc it describes at the beginning of the turn as tangential to the original course. There are, however, good reasons for believing that the curve described is more truly represented in the figure. It is certain that the stern of the vessel does not describe a curve to which the original course is a tangent, and of this we will be given one conclusive proof. If two ships are steaming in line ahead in smooth water, and the order is given to alter course in succession, say to starboard, the sternmost ship will see that the foremast of the headmost ship does not alter its bearing for some time after the stern has swung to port, and the wake of the leading ship will have a bend in it to port, which becomes an excellent mark for the sternmost ship to go by for putting over her own helm when she comes to this point. It is called the "kick." (See Plate IV, Fig. 2.)

The two things which oppose a ship's turning when the helm is put down, the ship steaming ahead, are *inertia* and *water-resistance.* They are remarkably different in effects, inasmuch as inertia, as an opposing element, is at its *maximum* when motion *begins*, and when water-resistance is at its *minimum.* Then, as we go on applying the accelerating force of rudder-power, or other force which has a moment about the pivoting point of the ship, we generate angular momentum, and then water-resistance. When we have once started the ship, so that every point in the middle line begins to revolve around the pivoting point, we get momentum of all the particles in the ship around this point. There are in fact moments of momentum set up by the first action of the rudder, which are added to the moment of rudder-power and increase as the angular velocity increases. But a check to this growing angular velocity is developed by the increasing resistance of the water. Then we have tending to turn the ship round on the pivoting point moments of momentum and moments of rudder-power, which are opposed by moments of water-resistance. It is evident that ultimately moments of momentum must be equal to moments of water-resistance, and that there will remain the constant force of the moments of rudder-power opposed also by equal moments of water-resistance, leaving no unbalanced forces, and so giving a uniform angular velocity to the middle fore-and-aft line of the ship, and she turns in a circle. This circle is spoken of as the *final circle.*

By absolute experiment it has been determined that the first quadrant of the circle is passed through in the quickest time, although the distance traversed is greater than in any subsequent quadrant. Until the final circle is entered upon, these three phenomena present themselves for every successive quadrant, less speed, shorter paths to traverse, and a longer time to perform that part of the turn.

Captain Colomb gives us a method for measuring the turning powers of the ship, which is as follows (some slight modifications have been made in the instruments used, others having been suggested, but the plan of the experiment has not been interfered with):

Choose a calm, still day in the open sea, but in view of a distant point of land or object sufficiently conspicuous for observation. Prepare two casks with flags or staffs, each flag to be of a different color. Care must be taken to weight the casks, so that a very few inches remain above water; this in order to prevent wind-drift, an element calculated to mar the accuracy of the experiment.

Alidades with dumb compasses or plane-tables, and sight-vanes or gun-directors, are to be placed one forward and one aft on the side towards which the turn is to be made. These sighting instruments are to be put the same distance from the fore-and-aft middle line of the ship. The distance between them to be as great as the length of the ship will allow. All angles observed will be reckoned from a *zero point*, which is right abeam. The distance between the sighting instruments is the base line of the triangle. The graduated ring of the standard compass and the alidade mounted thereon will be used for observing the distant point of land. Four observers are necessary; one to note the successive bearings of the distant point and change of direction of the ship's head for every 4 points, one to note the times, and one at each alidade to note the angles between the perpendicular to the base line and the bearing of the buoy about which the ship is turning.

All being in readiness, the two buoys are to be dropped about 1,500 yards apart, on a bearing convenient for observing the distant object at each point in the turn around either of them. A hand is stationed to sound the engine-room gong and another hand is stationed at the steam whistle or steam siren, if the ship is fitted with one. The engineers are ordered to note the engine counter at each sound of the gong, and the man at the whistle is directed to sound it at the orders, " Stand-by!" and " Stop!" the gong to the engine-room being struck at the order " Stop!"

The ship is now put on a course nearly parallel to the line of the buoys and at the speed desired. (See Plate V, Fig. 1.) One buoy is passed in this manner, but when the second buoy comes about 4 points on the bow, the observer, noting the time, gives the words, " Stand by!" and " Stop!" The siren sounds for each, and at the second, the helm is moved to the determined angle, the observer at the compass notes the position of the ship's head both by the compass and the bearing of the distant point of land, and the engineers note the engine counter, while the observers at the bow and stern note the bearing of the buoy. As the ship arrives at 4, 8, 12, and 16 points change of course, the observer at the compass in like manner gives the words, " Stand-by!" and " Stop!" when the siren or whistle sounds and the time, bearings, angles, and revolutions are taken.

When a series of observations completing the turn of 16 points is thus taken, the ship proceeds on a course nearly parallel to the line of buoys, and a turn of 16 points is made around the other buoy, either at the same speed and helm angle or with any desired variations of either or both. The experiment may, of course, be varied by stopping or reversing one or both engines in a vessel with twin screws at any point in the turn; and in all cases the exact position of the ship, when she has turned through 4, 8, 12, and 16 points, respectively, can be laid down from the observations. The method, Captain Colomb says, works exceedingly well and speedily, and is remarkably accurate.

The plan will be understood from Plate IV, Fig. 1, which represents an actual complete experiment. Here the ship has arrived on a straight course at the point P, then going 5 to 5½ knots with 35 revolutions. At this moment the helm is ordered 34° a port; the angles *abh* and *bah* are observed, the engine counter noted and the time taken. At d^1 the ship has turned by compass and bearing 4 points. At d^2 she has turned 8 points, and so on, and at each position the observations are repeated, the experiment being complete when the middle point of the ship is at d^4. The respective positions can easily be laid down to scale by a protractor with sufficient accuracy for practical purposes. The object of having two buoys is to save time and to allow the ship to recover herself on a straight cause before repeating the experiment.

It will be noted that this plan of measuring the turning-circle of a ship is only very good where the length of the ship is great, on account of the shortness of the base line.

V.

Mr. W. H. White, naval constructor, R. N., goes very thoroughly into the subject which we are considering, as may be seen by reading his lecture delivered before the Royal United Service Institute, a report of a portion of which is as follows:

> It is worth notice that when a ship is moving ahead under the assumed conditions in smooth water and a dead calm she is in *unstable equilibrium* so far as the maintenance of the straight course is concerned. That is to say, the action of a very small disturbing force will suffice to deflect her from that course. Directly the helm is put over, and an unbalanced pressure is developed on the rudder, that pressure constitutes a disturbing force, and the vessel begins to turn. Her angular motion is gradually accelerated as the helm angle is increased, and after the helm is "hard over." After reaching its maximum rate the angular motion of the vessel becomes uniform; and thenceforward if the helm angle and revolutions of the engines remain unaltered the vessel continues to swing round through equal angles in equal times, her center of gravity describing a circular path, and all other points moving in concentric circles. When there is powerful mechanical steering gear, capable of putting rudders of large area over to good angles in very small times, this condition of uniform angular motion is quickly reached, probably by the time the head of the ship has swung through 360° or even a less angle from the original course. With manual power at the helm, it is stated on good authority that similar uniformity of angular motion is not obtained until the ship has completed two circuits or even more. The longer time occupied in putting the helm over with manual power accounts for this difference.
>
> In order to determine the motion of the ship in turning it is convenient to take the following:
>
> (1.) The original straight course, as *line of reference*, from which to measure the angles turned through by the keel line of the ship in specified times.

(2.) The position of the center of the ship on the straight course at the instant when the helm begins to move over, as an *origin of co-ordinates.*

(3.) The path which the center of gravity describes while the ship turns, as that to be determined by observation. This will practically agree with the middle of the length in most ships.

It will be obvious that if by observation we can determine the place of the center of gravity at any instant with respect to the original course and the selected origin of co-ordinates, the path can be constructed. Also, that if the angles through which the head of the ship has turned are noted at the same times as the positions of the center of gravity are observed, the instantaneous positions of the keel line are found, and the instantaneous inclinations of the keel line to the corresponding tangents to the path of the center of gravity can be ascertained.

When the motion of rotation has become uniform, and the center of gravity is moving in a circle, the keel line of the ship makes a *constant* angle with the tangent to the circular path of the center of gravity. Plate IV, Fig. 3, illustrates this case. A represents the bow and B the stern of a ship. G shows the position of the center of gravity on the keel line AB. O is the center of the circular paths in which G, A, and B are moving. TGT_1 is the tangent to the path (G, G_1, G_2) of the center of gravity; and the angle (AGT) made by the keel line with the tangent is termed by the French *angle de dérive*, or "drift angle." The value of this drift angle varies considerably in different vessels, and in the same vessel under different conditions of speed and helm angle. In the Thunderer, for example, with a constant helm angle, but with variations in the speed, the following results were obtained:

Speed on straight.	Drift angle.	Diameters of circles (feet).	
		Bow.	Stern.
Knots.	°		
8.2	5¾	1,350	1,410
9.4	8¾	1,255	1,345
10.4	9¼	1,240	1,340
11.14	9½	1,240	1,340

Other cases are on record where the drift angle has been 16° or 18°. No general law has yet been formulated for the magnitude of the drift angle, but it is generally agreed that it increases (*a*) with increase in speed, when helm angle and rudder area are constant; (*b*) also with increase in rudder area and helm angle, speed being constant. As a consequence of the drift angle, the bow and stern of the ship revolve in circles of different diameters, and in the above table the results for the Thunderer furnish an illustration of the fact. Furthermore, in any given time the head of the ship must have turned through an angle from the original course which exceeds the angle turned through by the center of gravity by a quantity equal to the drift angle.

Turning again to Plate IV, Fig. 3, let P be the foot of a perpendicular let fall from the center O upon the middle line of the ship (AB). Then to an observer on board the ship, P will appear to be the "pivot point" about which the angular motion of the ship is being performed at each instant; for it will be seen that the keel line AB coincides with the tangent to the path of the point P, which is not true of any other point on the keel-line. In other words, at P there is no drift angle; whereas for every other point in the keel line there is a drift angle, the value of which is easily determined when that for the center of gravity, G, and the radius, OG, have been determined. In the case of the Thunderer the pivot point, P, varied from 67 to 103 feet before the center of gravity, or from about 80 to 40 feet from the stem. As the speed and drift angle increased, so the pivot point moved forward. It need hardly be added that the point G is the true center of the motion of the ship in turning, although P appears to an observer on board to be the pivot on which the ship turns during the time she has uniform angular velocity.

Another circumstance requiring notice in connection with the uniform turning motion now under consideration is the *loss of speed* sustained by the ship when turning, as compared with her speed on the straight course from which she began to turn. Taking several cases where this loss has been carefully measured, I find that the speed of advance on the circular path has only been *seven-tenths* or *eight-tenths* of the speed on the straight. It is often supposed that this loss of speed is chiefly due to the "drag" of the rudder. Any one who investigates the matter will become convinced that the rudder pressure has little to do with this considerable decrease in speed; the real cause is to be found in the drift angle. Glancing once more at Plate IV, Fig. 3, it will be evident that, at each instant, while the propelling force is delivered along or parallel to the keel line, the actual motion of the vessel in turning is not directly ahead, but sideways. In fact, the motion bears a considerable resemblance to the motion of a ship sailing on a wind; and there is a considerable pressure developed on the side of the bow most distant from the center, O. This pressure not merely checks the speed of the ship, but exercises a considerable turning effect, assisting the pressure on the rudder. The importance of this assistance will appear more clearly when it is considered that owing to the rotary motion of the vessel while turning, the flow of water at the stern is different, even in screw steamers, from that which would take place before the angular motion became considerable. In fact, the *effective* helm angle becomes considerably reduced from the angle RBD, Plate IV, Fig. 3, which the rudder makes with the keel line AB, produced. So far as I am aware, we have no exact data for estimating the amount of this reduction; but French experimentalists assert that it approaches to equality with the drift angle for the rudder axis B. If OB is joined, and BQ drawn perpendicular to it, then the effective helm angle, according to the French rule, should be taken as approximately equal to RBQ, and not to DBR, or a reduction of at least *one-half* from the angle made with the keel line, even in single-screw ships. Approximately the pressure on the rudder may be expressed as a function of the speed of the ship, and the *sine* of the effective angle of helm; so that the loss of rudder pressure consequent upon such a reduction in the effective angle as is asserted to take place will be very considerable. Apart from exact measures of the reduction, there can be no question as to the fact; and it is one of the matters upon which further experiments might well be made in English ships. With the assistance of a dynamometer to register the strains on the tiller end when the helm is first put over, and after the turning motion has become uniform, it would be an easy matter to discover the variations in the effective helm angle if the revolutions of the engines and speed of the ship were also observed.

In concluding these remarks on uniform angular motion, it may be well to refer to the *heeling* which accompanies turning. The forces which tend to produce heeling are as follows:

1. The centrifugal force acting outwards through the center of gravity of the ship and tending to make her heel away from the center of the circle.
2. The lateral component of the rudder pressure, acting through the center of pressure of the rudder at some depth below the center of gravity of the ship, and tending to make her heel inwards towards the center of the circle.
3. The lateral component of the fluid resistance on the outer side of the ship, which equals in magnitude the resultant of the centrifugal force and the rudder pressure, and acts through the center of lateral resistance.

Plate V, Fig. 2, shows the distribution of these forces in the Thunderer, determined from the turning trials made at Portland. Here again it is common to find the rudder pressure credited with the heeling effect; whereas it may, in most cases, be neglected in comparison with the centrifugal force. A fair approximation to the angle of heel for a ship in turning is given by the following equation:

$$\sin\theta = \frac{1}{32} \times \frac{d}{m} \times \frac{v^2}{R},$$

where θ = angle of heel,
v = speed of ship in feet per second,
R = radius of circle turned (in feet),
m = "metacentric height"—height of transverse metacentric above center of gravity,
d = distance of center of gravity above center of lateral resistance.

In the Thunderer, the center of lateral resistance was found to be from .43 to .49 of the mean draft below the water line; probably a fair approximation for war ships or ordinary form would be from .45 to .5 of the mean draft. From the foregoing equation it will be seen that—

The angle of heel varies (1) Directly as the *square of the speed* of ship;
(2) Inversely with the *metacentric height;*
(3) Inversely with the *radius* of the circle.

Hence it is obvious that ships of high speed, fitted with steam-steering gear, capable of turning on circles of comparatively small diameter, are those in which heeling may be expected to be greatest. Moderate values of the metacentric height further tend to increase the heeling. If the speed be *doubled,* the angle of heel will be about *quadrupled,* if the radius of the circle turned and the metacentric height remain constant. In order to maintain a certain angle of heel under these altered conditions of speed, the metacentric height would also have to be quadrupled; but such an increase in stiffness is clearly undesirable even if it were practicable. The following figures may be interesting:

	Speed on straight.	Diameter of circle.	Draft.	Metacentric height.	Angle of heel.
	Knots.	*Feet.*	*Ft. in.*	*Feet.*	° ′
Thunderer	8.2	1,340	26 3	3.12	0 52
	9.4	1,250	26 1		1 11
	10.4	1,240	26 1		1 14
Tourville (French)	15	2,030	....	....	3 30
Victorieuse (French)	10	1,290	....	....	2 0

It is important to notice that in taking observations of the angle of heel for a ship in turning, allowance must be made for the effect of the centrifugal force upon the indications of pendulums or clinometers. The error of indication is always in excess, and the correction is very easily made when the diameter of the circle and time of turning have been ascertained.

In treating at some length the case of a ship turning uniformly in a circular path, I have endeavored to clear the ground somewhat for the discussion of the more difficult case, which has far more practical importance, where the angular motion of the ship is not uniform and the path of her center of gravity is not circular. When the helm of a ship is put down, and she begins to turn away from a straight course, it is interesting to know (1) whether she will readily answer her helm; (2) what will be the path traversed by her center of gravity; (3) what will be the rate of growth of her drift angle; (4) what will be her gradual loss of speed as compared with her speed on the straight course. Probably the most important pieces of information in relation to naval tactics will be as follows: 1. The place of the center of gravity of the ship when her head has swung through 90° from her original course; that place being fixed (in the manner previously described) with reference to the original course and the position of the center of gravity thereon at the instant the helm begins to move over. 2. The speed of the ship when she has turned through the first 90°. 3. The time occupied in turning 90°. 4. The time and space required to reverse the course, turning through 180°.

It is singular to find on inquiry how meager is the information recorded on the first three of these points. I can discover no case except that of the Thunderer in which the actual path traversed by the center of gravity of the ship has been determined from the instant the helm was put down to the time when the turning motion had become uniform. All the facts as to these trials have been published in the report of the Inflexible committee, and they deserve the careful study of all naval officers. I do not propose to reproduce them there, but to use a few of the results only for purposes of illustration. Plate IV, Fig. 4, shows the course traversed by that ship, when turning from a straight path on which her speed has been 10.44 knots. On analyzing the companion diagrams for this speed, I find the following results, reckoning times from the instant when the helm was begun to be put over:

	Time.	At end of time.	
		Speed of ship.	Angular velocity per second.
	Seconds.	*Knots.*	° ′
To put helm over 31°	19	10. 4	0 20
To turn ship's head 45°	56	9. 25	1 18
To turn ship's head 90°	89	8. 3	1 18
To turn ship's head 135°	123	7. 75	1 15
To turn ship's head 180°	159	7. 5	1 12
To turn ship's head 360°	320	7. 14	1 6¾

At 360° the turning motion had become practically uniform. The conditions here traced for the Thunderer are representative for all steamships when turning under the action of their rudders from a straight course on which they were originally moving ahead. There will, of course, be differences in different ships as regards the times occupied in putting the helm down, or in passing through the various changes which precede the attainment of uniform angular velocity, as well as in the value of that velocity. But in all cases as a ship turns from her straight course she will be subjected to angular acceleration, her drift angle will gradually increase, she will heel more and more, and her speed will decrease. But by degrees these transitory conditions will pass away, if the helm is kept at a constant angle, and the engines at a nearly constant speed, and ultimately a state of uniform motion and steady heel will be reached such as I have previously attempted to describe.

Purely theoretical investigation does not enable one to lay down the path of the center of gravity of a ship from her straight course to the position occupied when the head has turned through 90°; nor are we much better off for the remaining part of her path until the turning becomes uniform. The greatest difficulty in framing the equations of motion arises from the uncertain state of our knowledge respecting the resistance offered by the water to the motion of the ship in turning. Hence it becomes necessary that the problem should be attacked by actual experiment, and careful observations made, which would enable the path traversed to be subsequently plotted. French writers assert that the curve traversed by a ship from the place where her helm is put over to her place when she has turned through 180°, can be treated without serious error as a circle touching the original course. The perpendicular distance from the place of the center of gravity when the head has turned through 180°, to the original course, is termed by the French the "diameter of evolution." Captain Colomb has proposed to call it the "tactical diameter." Unfortunately the Thunderer experiment shows that the French assumption as to the character of the curve is only a rough approximation; and apart from those experiments it is obvious that for different ships the character of the curve is likely to vary. Among the controlling circumstances which chiefly need attention are:

1. The area of the rudder, the maximum angle to which the helm can be put over, the rapidity with which it can be put hard over.
2. The speed of the ship or that of her propeller, as well as other causes influencing the flow of water relatively to the rudder, and the consequent development of an unbalanced pressure on the rudder, which exercises a turning effect on the ship.
3. The moment of inertia of the ship taken about a vertical axis passing through the center of gravity of the ship.
4. The moment of the resistance offered by the water to the lateral, rotary, and endwise motions of the ship.

It would be out of place for me to give any explanation of the causes which produce and determine the magnitude of the pressure on the rudder, since the matter is fully discussed in text books of naval architecture. Moreover, the ship comes into the hands of her commanding officer furnished with her rudder and steering gear, which have been tested in the constructor's trials. Experience may suggest improvements, of course; but, as a rule, the changes made are not great, and consequently in the management of the ship an officer can take advantage only of variations in the helm angle below a certain fixed maximum, and of variations in speed or direction of motion. It is generally agreed that—

1. Other things being equal, the turning effect of a rudder increases with an increase in the helm angle up to 40° or 45° with the keel line.
2. Other things being equal, the rate of acquisition of angular velocity, or the rapidity with which a ship turns, increases as the time occupied in putting the helm hard over is diminished.

Hereafter I shall mention a case or two illustrating the effect of putting the helm over more quickly upon the turning of ships; but as illustrations of the advantages of large helm angles, I may quote at once a few figures from actual trials. Admiral Sir Cooper Key found that the Delight gunboat behaved as under, when the helm angle alone was varied:

Helm angle.	Time of turning full circle.	Diameter of circle.
°	*Min. Sec.*	*Feet.*
10	3 52	615
20	3 18	405
30	2 57	275
40	2 47	205

Admiral Halstead, in the trials conducted with the floating battery Terror, obtained the following results:

Helm angle.	Time of turning full circle.
°	*Min. Sec.*
10	6 19
20	5 28
30	5 1
40	4 42

Lieutenant Coumes, of the French Navy, gives the following results for the iron-clad corvette Victorieuse, for an initial speed of about 12½ knots:

Helm angle.	Time of turning full circle.		Diameter of circle.
°	*Min.*	*Sec.*	*Meters.*
7	9	48	1,060
14	6	50	933
21	5	50	750
27	5	20	572
32½	5	20	475

Respecting the remaining circumstances enumerated above as affecting the turning motion, a very few remarks will suffice. In arranging the longitudinal distribution of the weights in a new ship, the naval architect cannot be governed by consideration of the effect which the *moment of inertia* has upon the turning qualities. But it is well known that if the weights are carried far away towards the ends of a ship, and her moment of inertia is great, she will be *slow* to *answer her helm*, as compared with a ship of similar form and equal displacement having the weights more concentrated towards the middle of the length.

Although the true character of the path traversed by a ship in turning has been determined in very few cases, it is known that it is more or less spiral up to the time that uniform angular velocity is reached. This departure from a true circle is of the character indicated in Plate IV, Fig. 4, and it places the ship, when she has turned through 360° and is again pointing in the original direction, somewhat to port or starboard of the original course, according as the ship is turning to port or starboard. The space occupied in turning through 180° and reversing the course has been termed the tactical diameter (*diamètre d'évolution*); it considerably exceeds the diameter of the circular orbit in which the ship turns after her motion has become uniform, or "final diameter" (*diamètre de gyration*). The reason is obvious; in the earlier part of the turning motion of the ship she is acquiring angular motion, that is to say, is subject to angular acceleration, and the curvature of her path is less pronounced than it is in the subsequent stages. It may be interesting to illustrate the ratio of the tactical and final diameters by a few figures drawn from actual trials:

	Helm angle.	Speed on straight.	Diameters.	
			Tactical.	Final.
	°	*Knots.*	*Feet.*	*Feet.*
Thunderer (English)	31	8.2	1,405	1,340
		9.4	1,320	1,250
		10.4	1,320	1,240
Victorieuse (French)	33	10.0	1,440	1,230

At present the published information on the ratio of tactical to final diameters is very limited; it is a subject to which further experiments may well be devoted. But for all practical purposes the determination of the tactical diameters is the more important. In the constructors' turning trials the diameter of the circle, as usually determined, is practically the tactical diameter, as will appear from the description given hereafter. With manual power and ordinary rudders the diameter of the circle for large ships has been found to vary between six and eight times the length of the ships; for small ships, wherein manual power suffices to put the helm over rapidly and the speed is low, the diameter falls to three or five times the length. For swift torpedo-boats, with manual power only at the helm and very small angles of helm, the diameter of the circle for full speed has reached about twelve times the length, and for half speed about four or six times the length. With manual power and *balanced* rudders the diameter for large ships has been reduced to four or five times the length; and nearly equal results have been obtained with ordinary rudders worked by steam or hydraulic steering gear. About three times the length is the minimum diameter yet obtained in large ships turning under the action of their rudders. These figures apply chiefly to full-speed trials; but it appears that differences of speed do not greatly affect the diameter of the circles, although they do affect the time of turning, so long as the time occupied in putting the helm hard over is nearly constant. For the same ship with the same angle of helm, and about the same time occupied in putting the helm over, the time occupied in turning the circle appears to vary nearly inversely as the speed. The time occupied in putting the helm hard over considerably affects the time of turning, and also influences the diameter of the circle. In the case of one of Her Majesty's ships, where the conditions remained almost unchanged, except that a steam steering engine was fitted, and the time occupied in putting the helm hard over was reduced from 90 seconds to 20 seconds, the time occupied in turning the circle was reduced from 8½ minutes to a little over 7 minutes, and the diameter of the circle was reduced from 970 yards to 885 yards. Before steam steering engines became common in the Royal Navy balanced rudders furnished the best means of putting a large rudder area over quickly to a large angle, and the Bellerophon, Hercules, Monarch, and other vessels so fitted performed admirably in turning under steam. But now that mechanical steering appliances are available, ordinary rudders, hinged at their fore edge, are once more preferred, because they are simpler and less liable to derangement than balanced rudders, besides being more suitable for use in ships having sail as well as steam power.

The determination of the tactical diameter is an important matter, but it does not furnish a complete or sufficient account of the space necessary for a ship to reverse her course; for it gives only a measurement at right angles to the original course—which may be termed the "transfer" of the ship—and affords no measure of her "advance" in the direction of her original course. Taking the case of the Thunderer (Plate IV, Fig. 4), it appears that, reckoning from the instant when the helm began to move over, the ship *advanced* about 1,000 feet in the direction of her straight course before her head had swung through 90°, and was *transferred* (at right angles to her course) about 700 feet. When her head had turned through 180° and the course was reversed, the *advance* had been reduced to 520 feet, while the *transfer* (or tactical diameter) had increased to 1,320 feet. It is most important to ascertain the advance and transfer for the 90° position; the necessary observations are easily made, and I shall not occupy space with a description of any one among the many methods that might be used.

Passing from these general considerations, I will now endeavor to sketch briefly the methods adopted for measuring the diameters of the circles turned by ships on their constructors' trials.

The first is that commonly used in trials of Her Majesty's ships; it was introduced about fifteen years ago by Mr. Martin, chief constructor of Pembroke dock-yard, and is illustrated by Plate V, Fig. 3.

At any assigned place in the length of the ship two vertical battens, *b*, *b*, are fixed in the same transverse plane, and an observer is stationed at the position fixed by one of these battens. A second observer is stationed at B, at a certain longitudinal distance, *l*, from the first observer, and this second observer has to operate a very simple instrument for measuring angles, which is shown on a larger scale in Plate V, Fig. 5. The zero line of this measuring instrument is made to coincide with, or be parallel to, the middle line of the ship. When the helm begins to move over, a box, C, is thrown overboard from the station *b*, at which the fixed battens are placed. After the ship has turned through such an angle that the line joining the two fixed battens again bears upon the box C, a signal is made to the second observer, who instantly notes the angle (ABC) which the line of sight to the box C makes with the zero line of his measuring instrument; let this angle be termed a. Then a simple trigonometrical ratio gives—

$$\text{Diameter of circle} = l \tan a,$$

if the semicircle is supposed to be completed when the angle a is measured. This is a good practical method for smooth water and a calm. Obviously it takes no account of a possible drift of the box, and it assumes the omission of the "drift angle" for the ship, on the supposition that the semicircle of rotation is not completed until the line joining CD is a diameter of the circle. As a matter of fact, owing to the creation of the drift angle, the head of the ship will have turned through 180° *before* her center of gravity has traversed so large an arc in its path. The amount of this possible error in most large ships is not great, and for ascertaining the diameter of the circle simply the plan is a good one. It may be added that since the diameter determined is for the points in the ship at which the fixed battens are placed, by fixing them first at the bow and next transposing them to the stern it would be possible to ascertain the diameters of the respective circles for the bow and stern, and thence to determine the drift angle approximately.

Lieutenant Coumes, of the French Navy, has recently published an extension of the English method, which deserves to be widely known. It is illustrated in Plate V, Fig. 4. He assumes the path of the ship from the straight course to a little beyond the place where she has turned through 180° to be an arc of a circle. At the position C, a buoy is dropped overboard abreast the fixed battens, just as is done in the English plan. At the position marked D the head of the ship has swung through 180° and the line joining the two fixed battens bears upon the box at C. An observer stationed at B, at a known distance from the fixed battens, notes the value of the angle ABC (α) at that instant, and simultaneously a second box, D, is dropped overboard. The ship moves on to a position, E, a little beyond D, and the observer stationed at the fixed battens notes the angle EDC (β), which the two boxes, C and D, then subtend. These are all the observations needed. Suppose O to be the center of the circular path, join CO and produce it to meet the circle at F, also join DF. Then the angle, DFC, is equal to β, being in the same segment, and the angle, CDF, being in a semicircle, is a right angle. Hence—

$$\text{Diameter of circle} = \text{CD} \times \operatorname{cosec} \beta.$$
$$\text{Diameter of circle} = l \tan.\, a \operatorname{cosec} \beta.$$

Further, it will be seen that the drift angle (δ) equals the angle CDO, which is equal to DCO, and is therefore the complement of β.

The maximum correction produced by substituting Lieutenant Coumes's method for Mr. Martin's in estimating the "tactical diameter" is expressed by the product of the radius into the versed sine of the angle of drift, or algebraically—

$$\text{Error} = \text{radius} \times \text{versine } \delta,$$

where δ varies between 10° and 20° and versine δ varies between .015 and .06. This correction is evidently of little importance in most cases.

Another plan, which has been extensively used in estimating the diameter of the circles turned, is to tow a patent log astern and note the distance it registers while the ship turns through 360°. This registered distance is afterwards treated as the circumference of a circle, and the diameter is obtained by a simple calculation. Opinions are divided as to the trustworthiness of this plan. I do not pretend to be in a position to decide the matter, but feel confident that the chances of error must be greater than in the geometrical methods above described. Even with the best logs available towed behind a vessel moving at a varying speed and turning, there must be great danger that their indications will vary with differences of speed or will be affected with the wake of the vessel. The French have made comparative trials of the geometrical method and of log-measurement, the result being unfavorable to the latter.

Still another plan, well adapted for small vessels, is that devised by Sir Cooper Key and used in the turning trials of Her Majesty's gunboat Delight, conducted at Devonport in 1863. The register of a Massey's patent sounding machine was removed from the lead and attached to a long staff. At the commencement of a circle the register was immersed, when the circle was completed it was immediately raised. The distance registered was read off, and this was treated as the circumference of the circle traversed.

In the French squadrons of 1864-'66 the turning trials were conducted differently from any of the foregoing methods. Captain Bourgois gives the particulars in his pamphlet previously noticed; it may be briefly described as follows: One ship of the squadron was anchored, and the vessel whose movements were to be recorded turned about the stationary vessel. Two observers were stationed at a known distance apart on board the moving vessel. At frequent and regular intervals of time these observers noted simultaneously and recorded the angular elevation of a mast head in the anchored vessel. The height of this mast head above the water being known, this series of observations gave the distances of the anchored ship from each observer at each time of observation. Meanwhile observers stationed on board the anchored vessel took frequent and simultaneous observations of the angular elevations and bearings of a mast head in the ship that was turning. And further, other observers on board the moving ship noted at frequent intervals the angles subtended by a mast in the anchored ship with some fixed and distant object. These observations would have sufficed to determine the path traversed by the ship from the time her helm was put down; but it is a remarkable fact that the important motions of the ships through the first 90° of rotation were designedly neglected, and the observations were begun only when approximately uniform circular motion had been attained. On the other hand, it is in these records one finds attention first given to the importance of determining the drift angle.

The French appear to attach great importance to the determination of the tactical diameter corresponding to various revolutions of the screw and various helm angles for individual ships. I leave naval officers to say what this knowledge may be worth in its bearing upon the movements of the ships composing a squadron; but it is obvious that if the ships are of various sizes and types, combined movements under steam can be performed with greater uniformity if the admiral has this kind of information for all the ships under his command. Perhaps it may be as well to add that the plan which has been sometimes adopted for estimating the diameter of the circle turned by counting the revolutions of the engines, and thence deducing the speed, is liable to lead into serious error. Owing to the drift angle the speed corresponding to a given number of revolutions is much less when a ship is turning than it is when she is on a straight course. In the Thunderer, for example, a speed of 10.4 knots was obtained with 65 revolutions, whereas on the circle 59 revolutions only gave a speed of 7.14 knots.

In concluding these remarks on methods of recording the behavior of ships when turning, I may be permitted to add that in the trials with the Thunderer the method of procedure embraced many of the foregoing principles, and enabled a most searching check and counter-check to be put upon the observations. Any officer familiar with nautical observations will find no difficulty in arranging his own programme should he decide to accurately determine the path of his ship in turning under certain assumed conditions. But he can only derive benefit from a study of what was done in the Thunderer, the report of the trials of that ship containing the most thorough information yet published on this subject.

It is impossible to discuss the "Turning Powers of Ships," even in the outline to which I am compelled to confine myself in the present paper, without referring to the maneuvering power given to a ship by *duplicate propellers*, and more especially by twin screws. Twin screws are now almost universally adopted in the most powerful war ships, and their efficiency as propellers is well established. But they have the further advantage of enabling a vessel, by reversing one of her screws while the other drives her ahead, to turn in a very small circle—almost in her own length. The rate of turning under these circumstances is often slow, but the power of giving rotation to a ship practically destitute of headway and independently of the rudder is of great value. Twin screws are, of course, associated with rudders, and no one at all conversant with the subject would propose to trust to twin screws alone for maneuvering purposes. They are really only valuable auxiliaries to the rudder, and in no sense rivals to it.

It may be interesting to add, with regard to the turning effect of twin screws when working in opposite directions, that in deep-draft ships the time occupied in turning is usually greater than the time for turning the circle with both screws working ahead at full speed; whereas for shallow-draft ships the corresponding difference in time is small. For example, in the Captain, the time for circle at full speed ahead was 5 minutes 24 seconds; that for circle with screws working in opposite directions, 6 minutes 52 seconds. In the shallow-draft gunboats of the Medina class, on the other hand, the full-speed turning trial gave about 3 minutes 6 seconds for the circle, and with screws working in opposite directions the time was only 3 minutes 13 seconds. It will be obvious that in the shallow-draft ships the ratio of the moment of resistance to rotation to the turning moment of the screws is much less than the corresponding ratio for deep-draft ships.

Trustworthy data are much needed respecting one feature in the steerage of twin-screw ships. It is well known that with one screw only at work a small angle of helm will keep a twin-screw ship on a straight course; and this is a proof of the moderate turning moment obtained with twin screws working in opposite directions. But I have searched unsuccessfully for records of exact experiments determining what angle of helm suffices to balance one of twin screws working alone; and I shall be much indebted to gentlemen who may be good enough to give me the needed information. The facts to be noted are very few and simple, viz: (1) the revolutions of the screw; (2) the speed of the ship; (3) the angle of helm required to keep the vessel straight.

When I speak of the moderate turning effect of twin screws, it will be understood that I have in mind the corresponding effect of even a small rudder at a small angle, in a ship steaming at full speed ahead. The normal pressure on such a rudder will be considerable when compared with the thrust of a screw; but the greatest gain for the rudder pressure is the *leverage* with which it acts. Roughly speaking, this leverage is equal to the product—*half length of ship* × *cosine of helm angle;* whereas for the twin screws the corresponding leverage is only about equal to the tranverse distance between the screw shafts, or less than one-half the extreme breadth of the ship. It must not be forgotten, however, that for the rudder to act most efficiently, a ship must have good headway; whereas in the twin-screw ship there is a possibility of turning with very little motion ahead.

The steering effect of a single screw, which has the greatest practical interest, is that in ships where the rudder is placed abaft the screw. It is well known that, in such cases, if the screw be turned ahead or astern when a vessel is at rest, the impact of the screw-race upon the rudder will give steerage power before the vessel has acquired sensible headway. By this means it is possible to slew a single-screw ship round in a very limited space in calm weather, although the operation is a very tedious one. But there is another steering effect of a single screw independent of the rudder, with which sailors are familiar; I mean the effect which produces a turning motion in a ship of which the helm is kept amidships while the screw revolves. The principal causes of this turning motion are (1) the difference of the transverse thrust on the blades of the screw in the upper and lower halves of their orbit; (2) the difference in the lateral pressures, due to the momentum of the streams delivered by the upper and lower blades of the screw upon the stern-post and body of the ship. The ordinary result in ships of the royal navy is that with *well-immersed* screws, the head of the ship turns in the same direction as the *upper* blades of the screws move; but that with screws which are near the surface, or which sweep above the surface, the contrary holds good, and the head of the ship turns in the direction in which the lower blades are moving. I am aware that there are exceptions to these rules, but think they generally hold good for ships moving *ahead*. When the screws are turning astern, the conditions are altered materially.

Auxiliary rudders of many kinds have been proposed and tried. In the museum of naval models at the Royal Naval College, Greenwich, a good collection of these plans may be seen, and it shows how frequently an invention is reinvented by persons who have the same object in view, but are working in ignorance of what has been done by their predecessors. I have only space to allude to the most recent and most successful trials of auxiliary rudders made in the Comus class of the royal navy. These vessels have an ordinary rudder at the stern, and an auxiliary rudder fitted in a recess in the after part of the hull below the screw shaft. This auxiliary rudder has side plates fitted at some distance from the body, on the plan proposed by M. Jöessel, of the French Navy. On trial it was found to answer fairly, keeping the vessel under control, although its effect did not compare favorably with that of the main rudder; nor was this anticipated, since the rudder is fitted as an auxiliary only for use when the main rudder is disabled in action.

The steerage of a screw steamship having engines reversed, while she has either *headway* or *sternway*, supposing her to be fitted only with an ordinary rudder at the stern, is a subject for experimental inquiry rather than for mathematical investigation. It is easy to see what causes are in operation tending to control the behavior of the vessel; but these causes are so conflicting and variable as to make any general statement of little value. The following extract from the report of the committee appointed by the British Association "to investigate the effect of propellers on the steering of vessels," may be read with interest, as it represents the conclusions reached after a considerable number of experiments had been made by Prof. Osborne Reynolds and other members of the committee:

"It appears both from the experiments made by the committee, and from other evidence, that the distance required by a screw steamer to bring herself to rest from full speed by the reversal of her screw is independent, or nearly so, of the power of her engines, but depends upon the size and build of the ship, and generally lies between four and six times the ship's length. It is to be borne in mind that it is to the behavior of the ship during this interval that the following remarks apply.

"The main point the committee have had in view has been to ascertain how far the reversing of the screw in order to stop a ship did, or did not, interfere with the action of the rudder during the interval of stopping; and it is as regards this point that the most important light has been thrown on the question of handling ships. It is found an invariable rule that, during the interval in which a ship is stopping herself by the reversal of her screw, the rudder produces none of its usual effects to turn the ship; but that under these circumstances the effect of the rudder, such as it is, is to turn the ship in the opposite direction from that in which she would turn if the screw were going ahead. The magnitude of this reverse effect of the rudder is always feeble, and is different for different ships, and even for the same ship under different conditions of lading.

"It also appears from the trials that, owing to the feeble influence of the rudder over the ship during the interval in which she is stopping, she is then at the mercy of any other influences that may act upon her. Thus the wind, which always exerts an influence to turn the stem (or forward end) of the ship into the wind, but which influence is usually well under control of the rudder, may, when the screw is reversed, become paramount, and cause the ship to turn in a direction the very opposite of that which is desired. Also the reversed screw will exercise an influence which increases as the ship's way is diminished to turn the ship to starboard or port, according as it is right or left handed; this being particularly the case when the ships are in light draft.

"These several influences, the reversed effect of the rudder, the effect of the wind, and the action of the screw, will determine the course the ship takes during the interval of stopping. They may balance, in which case the ship will go straight on; or any one of three may predominate and determine the course of the ship. The utmost effect of these influences when they all act in conjunction, as when the screw is right handed, the helm starboarded, and the wind on the starboard side, is small as compared with the influence of the rudder as it acts when the ship is steaming ahead. In no instance has a ship tried by the committee been able to turn with the screw reversed on a circle of less than double the radius of that on which she would turn when steaming ahead. So that even if those in charge could govern the direction in which the ship will turn while stopping, she turns but slowly, whereas in point of fact those in charge have little or no control over this direction, and unless they are exceptionally well acquainted with their ship they will be unable even to predict the direction."

There is much in these conclusions which has been well known for many years to men engaged in handling screw steamers; and trials were made in the Great Britain to determine the effect of the screw race upon the steerage. But no one can look through the reports of the committee from which the above quotation is made without feeling that their experiments are very valuable and deserving of being carefully studied by all officers in command of screw steamships. Differences of opinion which exist as to the wisdom of some of the recommendations for avoiding collisions made by the committee will not prevent any one interested in the subject from acknowledging the great merits of the work done by the committee, or at its request.

Throughout this paper it has been assumed that the ship's maneuvering capabilities are ascertained in smooth water and in a calm or light breeze. These are the conditions most suitable for exact experiments and comparison; but I need hardly say that such trials do not represent the conditions of actual service. It would be idle to attempt any discussion of the influence which the wind and sea have upon the turning powers of ships, since that influence is so variable. But, on the other hand, it must be remembered that the principles previously laid down for turning in smooth water hold good also in a seaway; only the effects of the rudder, of the inertia, and resistance are then supplemented by the effects of wind and sea. This branch of the subject is, in fact, one of seamanship, and not one to be discussed by the naval architect.

The general conclusions to which my study of the subject of this paper has led me may be briefly summarized as follows:

(1.) On the whole, the ordinary rudder hung at the stern of a ship has not been equaled for maneuvering purposes when a ship has *headway*.

(2.) When associated with steam or hydraulic steering gear the ordinary rudder hinged at its forward edge to the stern-post is to be preferred to all other kinds of rudders. Balanced rudders are chiefly useful, if mechanical steering gear is not available, in large ships.

(3.) Twin screws furnish the best combination of economical propulsion with maneuvering power which has yet been produced.

(4.) The various inventions hitherto tried for rendering the trust of a single propeller available for maneuvering purposes involve risks and drawbacks too serious to be encountered in large ships, although the contrary may be true in small crafts.

(5.) Bow rudders are chiefly useful to assist steerage in ships moving astern Balanced or "drop" bow rudders are to be preferred for use when ships are moving ahead.

(6.) It is desirable that further and careful observations should be made of the actual behavior of ships when turning at various speeds and with different helm angles. Accurate plottings of the path traversed while the head of the ship swings through he first 90° from her original course are especially needed.

Turning experiments with the steamship Hankow, copied from the report of the British Association Committee for Inquiry into the steering of steamships, 1877.

The Hankow is a single-screw steamship, of 3,594.12 gross tonnage; net, 2,331.75 tons;, length, 389 feet; breadth, 42 feet 1 inch; depth, 28 feet 8 inches.

Her propeller is four-bladed, right-handed, with a diameter of 20 feet, and a pitch from 24 to 26 feet. The mean angle of its surface with a vertical athwartship plane would be 21°, hence the streams would be delivered on an average at an angle of 21° from the vertical fore and aft plane.

Experiments were conducted on March 8, 1877, in lat. 8° 50′ S., long. 153° 58′ E., between 9.20 and 11.30 a. m., as follows:

Sea smooth, or between 1 and 2 of Beaufort scale; ship drawing probably 24 feet 8 inches forward and 23 feet 8 inches aft.

FIRST EXPERIMENT.

Ship going ahead full speed (say 10 knots), engines were suddenly reversed, helm put hard aport; immediately the engines started, time noted, and bearing of ship's head by standard Admiralty compass noted, and the bearing of the ship's head also noted at every 15 seconds, until the ship came to a dead stop.

Time.			Interval.		Ship's head by compass.	Head turned to—	
						Port.	Starboard.
h.	*min.*	*secs.*	*m.*	*secs.*			
9	20	7	....		N. 62 W.	....	....
9	20	22	0	15	N. 62½ W.	0½	....
9	20	37	0	15	N. 66 W.	3½	....
9	20	52	0	15	N. 69 W.	3	....
9	21	7	0	15	N. 73½ W.	4½	....
9	21	22	0	15	N. 77 W.	3½	....
9	21	37	0	15	N. 80 W.	3½	....
9	21	52	0	15	N. 84½ W.	4	....
9	22	7	0	15	N. 88 W.	3½	....
9	22	22	0	15	N. 88 W.	Stationary.	....
9	22	37	0	15	N. 87 W.	....	1
9	22	52	0	15	N. 85½ W.	....	1½
9	23	7	0	15	N. 84 W.	....	1½
9	23	22	0	15	N. 82½ W.	....	1½
9	23	37	0	15	N. 79½ W.	....	3
0	3	30	3	30	....	26	8½

Ship came to a dead stop in 3 m. 30 secs., and turned to port 26° in 2 m., and then to starboard 8½° for 1½ m.

SECOND EXPERIMENT.

Ship going ahead full speed, say 10 knots. Engines suddenly reversed to full speed astern; helm put hard astarboard, bearing on ship's head taken, and time as before.

Time.			Interval.		Ship's head by compass.	Head turned to—	
						Port.	Starboard.
h.	*min.*	*secs.*	*m.*	*secs.*			
9	45	30	....		N. 3 W.	....	....
9	45	45	0	15	N. 21 W.	2	....
9	46	0	0	15	N. 41 W.	Stationary.	....
9	46	15	0	15	N. 49½ W.	....	1½
9	46	30	0	15	N. 37½ W.	....	2
9	46	45	0	15	N. 32½ W.	....	5
9	47	0	0	15	N. 38 W.	....	4½
9	47	15	0	15	N. 24½ W.	....	3½
9	47	30	0	15	N. 21½ W.	....	3
9	47	45	0	15	N. 28 W.	....	3½
9	48	0	0	15	N. 13 W.	....	5
9	48	15	0	15	N. 19 W.	....	4
9	48	30	0	15	N. 5 W.	....	4
9	48	45	0	15	N. 2½ W.	....	2½
9	48	53	0	8	N. 2 W.	....	0½
0	3	23	3	23	....	2	39

Ship came to a dead stop in 3 m. 23 secs. Her head payed off to port 2° during the first 15 secs., and afterwards turned to starboard 39° before coming to rest.

THIRD EXPERIMENT.

Ship going full speed ahead, say 10 knots, the engines suddenly reversed to full speed astern the helm put amidships, the bearing of ship's head noted by azimuth compass as before. Sea, wind, and weather as before.

Time.			Interval.		Ship's head by compass.	Head turned to—	
						Port.	Starboard.
h.	*min.*	*secs.*	*m.*	*secs.*			
10	34	16	....		N. 29½ E.	....	....
			0	15	N. 29 E.	0½	....
			0	15	N. 29½ E.	....	0½
			0	15	N. 30½ E.	....	1
			0	15	N. 32 E.	....	1½
			0	15	N. 36 E.	....	4
			0	15	N. 39 E.	....	3
			0	15	N. 44 E.	....	5
			0	15	N. 46½ E.	....	2½
			0	15	N. 48 E.	....	1½
			0	15	N. 50½ E.	....	2½
			0	15	N. 51½ E.	....	1
			0	15	N. 52 E.	....	0½
			0	15	N. 53½ E.	....	1½
			0	15	N. 54 E.	....	0½
			0	15	N. 54½ E.	....	0½
			0	15	N. 55 E.	....	0½
10	38	31	0	15	N. 56 E.	....	1
0	4	15	4	15	....	0½	27

Ship came to absolute rest in 4 m. 15 secs.; her head turned to port 0½°, and then 27° to starboard, before coming to rest.

FOURTH EXPERIMENT.

In this case ship was going full speed astern, say about 9 knots, when the engines were suddenly reversed to full speed ahead; helm put hard to port; time and azimuth of ship's head noted as before. Sea, wind, and weather as before.

Time.			Interval.		Ship's head by compass.	Head turned to—	
						Port.	Starboard.
h.	*min.*	*secs.*	*m.*	*secs.*			
11	3	11	......		S. 65½ E.	......	......
			0	15	S. 66 E.	0½	......
			0	15	S. 67 E.	1	......
			0	15	S. 67½ E.	0½	......
			0	15	S. 67½ E.	Stationary.	......
			0	15	S. 66½ E.	......	1
			0	15	S. 65½ E.	......	1
			0	15	S. 63½ E.	......	2
			0	15	S. 60½ E.	......	3
			0	15	S. 57½ E.	......	3
			0	15	S. 53½ E.	......	4
11	5	56	0	15	S. 48 E.	......	5½
0	2	45	2	45	......	2	19½

Ship came to dead stop in 2 m. 45 secs., and her head turned 2° to port in the first 45 secs., and 19½° to starboard in the next 2 minutes.

FIFTH EXPERIMENT

Making the circle from rest; hard to port; full speed ahead. Wind and sea as before.

Ship started at full speed from absolute rest, with the helm hard aport, and at the instant of starting an empty flour barrel was dropped from the stern, to mark the point started from.

Time.			Interval.		Ship's head by compass.	Arc turned.
h.	*min.*	*secs.*	*m.*	*secs.*		
9	27	54	......		N. 56½ W.	......
	28	24	1	30	N. 54 W.	2½
	28	54	0	30	N. 49 W.	5
			0	30	N. 38 W.	11
			0	30	N. 28 W.	10
			0	30	N. 18 W.	10
			0	30	N. 5 W.	13
			0	30	N. 6 E.	11
			0	30	N. 19 E.	13
			0	30	N. 30 E.	11
			0	30	N. 43½ E.	13½
			0	30	N. 58 E.	14½
			0	30	N. 74 E.	16
			0	30	N. 89 E.	15
			0	30	S. 75 E.	16

Time.			Interval.		Ship's head by compass.	Arc turned.
h.	*min.*	*secs.*	*m.*	*secs.*		
			0	30	S. 61 E.	14
			0	30	S. 46½ E.	14½
			0	30	S. 33 E.	13½
			0	30	S. 20 E.	13
			0	30	S. 7½ E.	12½
			0	30	S. 4½ W.	12
			0	30	S. 16½ W.	12
			0	30	S. 30 W.	13½
			0	30	S. 45½ W.	15½
			0	30	S. 61 W.	15½
			0	30	S. 78½ W.	17½
9	40	54	0	30	N. 84 W.	17½
9	41	24	0	30	N. 67 W.	17
9	41	40	0	16	N. 57 W.	10
0	13	46	13	46	....	Mean angular velocity, 27′ per second.

Ship came outside barrel about 150 feet, when it was abreast taffrail, *i. e.*, it was on our starboard side at conclusion.

VI.

Among the methods suggested to find the qualities of the turning circle is one by Lieut. A. B. Wyckoff, U. S. N., for determining the drift angle and final diameter, which is as follows:

Have two cross-battens erected on the topgallant forecastle, and two observers—one at the cross-battens and the other at the after end of base-line on the poop-deck. At instant of putting helm over drop a buoy abreast cross-battens and note the time. (See Plate V, Fig. 6.) When the vessel has turned through 90° drop a second buoy abreast cross-battens, and take the angles a and b subtended by the first buoy and the opposite end of the base-line. Note the time when the second buoy comes abeam (position 3) by the cross-battens, take angle z, subtended by the second buoy and the forward end of base-line. Note time when ship has turned through 32 points.

$$l = \text{length of base line } P^1\,B$$

$$P\,P^1 = \frac{l \sin b}{\sin n}$$

$$P^1\,P^2 = l \operatorname{tang} z$$

$$T\,P^1 = P\,P^1 \cos a$$

$$T\,T^1 = \frac{P^1\,P^2}{2} + T\,P^2$$

$$\operatorname{Tang} c = \frac{P^2\,H^1}{R} = \text{drift angle}$$

$$R = \frac{P^1\,P^2}{2} \text{ half final diameter.}$$

VII.

In regard to the evolutionary powers of a vessel fitted with a steering propeller we propose to look a little into a type of vessel possessed by our Navy—we mean the Alarm. Without discussing her construction or engining, we will merely say that she has much to recommend her *tactically:* for instance, her great facility of turning; but this quality, with any sort of steering propeller, must be at the expense of speed. The action of the screw can be referred to any radius of a circle, and therefore the vessel can be pushed or pulled in any direction. Her motion indeed may be compared to a man standing between the handles of a wheelbarrow, since her pivoting point is in the bow. She will be comparatively safe from ramming in a single combat, since she can keep her bow constantly on the enemy. She will be able to ram an antagonist of greater speed, if he be fitted with a single screw, as she can make the *chord* of the segment of a circle in turning, where her adversary must run on the circumference. On a straight course, however, a vessel of less speed can overtake the Alarm, from the fact that her speed is reduced by the *eagerness* with which she answers her propeller, and the consequent reduction in the length of her forward moment due to the screw not always acting in the direction of her keel.

CHAPTER V.

THE SHIP IN ACTION ON THE OPEN SEA.

I.

Most authorities agree that during an action the highest speed should be maintained by the ship; that speed is of even greater moment to a ram than handiness or turning power, and that a powerful stern fire is at least as important as a powerful bow fire.

It is a fundamental principle of warfare that in single combat a fast ship need never be rammed by a slower one; indeed, if the turning powers are equal, the faster ship can *always* ram the slower one; and, also, the enemy should always, if possible, be put in a position to leeward of the attacking ship, so that the smoke from the guns and funnels combined will blind him. It follows as a postulate that should a vessel unfortunately be placed in this position, befogged with smoke, she should stop firing, so as not to add to her difficulties. It may be observed, however, that some of the best tacticians do not see in this leewardly position all the disadvantages charged against it.

Lieut. G. R. Bethell, R. N., says, in regard to the speed to be maintained in action, that unquestionably vessels should be capable of the very highest speed. There are cases, though, where slow speed will be used; as, for instance, two vessels running side by side, each would naturally tend to slow and turn toward her adversary, as neither could advisedly permit the other to enter her wake close astern.

II.

The increase in speed of ships, and the rapidity with which they will move in future fights, obliges us to look to every means of increase in the quickness of fire, so that we may hit the enemy as many times as possible in a given time. Actually, a 27-centimeter gun can fire once in three minutes under favorable circumstances, but in battle it will only be fired probably once in four minutes. The limited amount of ammunition that can now be carried raises the question whether very quick fire will be resorted to and maintained. A sea-fight will probably last such a short time and be so decisive that we think there should be no limit to this rapidity. During a bombardment the vessels of a squadron will have to be supplied by a regular ammunition supply-service from ammunition vessels. Some vessels have guns of such size that only fifty rounds can be carried for each. A German authority believes that ships of this kind are not fitted for the line of battle, and it may be added, that the majority of professional writers agree with him on this point. The precision of fire is of no less importance than the rapidity, the necessity of seizing the instant, generally very short, when you can get your enemy in a position to strike him hard and with certainty must not be lost, as projectiles are provided too few in number and are too costly to be thrown away.

The probabilities in favor of striking the side of an ordinary armorclad of the first-class with a large calibered gun are about 95 in 100 for 2,200 yards; 40 in 100 for 4,400 yards, and 15 in 100 for 6,500 yards, supposing the pointing to be perfect and the only marring element to be the motion of the ship.

Captain Rivet, of the French Navy, says that the precision of fire depends upon the following:

1. Relative movements of the two ships.
2. The smoke from the guns and funnels of your own and the enemy's ships.
3. The pitching and rolling of the ship firing.
4. The uncertainty of the intervening distance.
5. The action of the wind.
6. The state of the nerves of the firer, from his knowing that the instant he discharges his battery the enemy will do the same.

The methods in use to measure distances are very imperfect, and the variations of distances are very rapid, owing to the high speed of the combatants. Rolling exercises its worst influence on covered-in guns. It is recommended, in effect, as a general rule, not to fire a gun when the ship is half way on a roll. Now, it may happen that the battery may be concentrated beforehand on a point on a certain bearing, and with a certain elevation, and when the enemy is at this spot the broadside should be fired; but if at this instant the ship was at such a part of her roll as to change the elevation the whole effect of the broadside would be lost.

According to Captain Rivet the use of artillery in a naval fight can be reduced to the following rules:

1. The fire of pieces from uncovered decks, or guns in barbette, should be independent. Guns on covered decks should be fired by broadside and concentrated fire used.
2. Barbette fire of the lighter guns should be directed by preference at the decks, and at the non-protected parts of the ship. The battery and heavy guns should be directed at the water line.
3. If the sea is heavy and the vessels are rolling deeply, the firing-officer should carefully watch the motion when the enemy is on the brink of arriving at the focus of concentration.

4. As soon as the gun is laid the crew should cover. As soon as the gun is fired it should be loaded, laid, and the crew should cover.

5. If the broadside battery has great power of penetration it is best to fire each gun in succession. If the wind is ahead, commence aft. If the wind is aft, commence forward. Keep, if possible, between the sun and your adversary.

6. Guns should only be used when there is a probability of their producing a serious effect on the enemy.

7. Machine guns and small-arms on deck and aloft should fire on those parts of the enemy where it is suspected the captain and controlling officers are located, at semaphore stations on the deck, and at the points where the electric lights are installed.

Besides heavy artillery, ships are furnished with lighter guns that at most weigh four tons. In a fight the larger of the lighter guns will aim at the non-protected parts of the ship and the screw. The smaller of the lighter guns and the machine guns will keep up a shower of projectiles, when near the enemy, on her decks; or, if there is an attack from the enemy's torpedo boats, these guns should drive them off. Machine guns and small-arms should be used from aloft. As a quantity of small-arm ammunition will be used, there must be a regular force of supply-men, who shall serve ammunition to the machine guns and small-arm men from the small-arm magazine.

It may be suggested that the expanding quality of seed when wet might be taken advantage of to stop shot-holes. A long canvas cylindrical bag might be made and used like a jackass, partially filled with seed or grain. Until the seed has swelled a safety mat must be kept over the aperture. It may here be mentioned that all vessels, at all times, should keep one or more small hogging lines rove.

III.

The ram is the most formidable of all the weapons of the ship, and its use requires severe and prolonged practical study. The time has come when a commanding officer must be as dexterous in the handling of his ship as is a fencing-master in the use of his foil.

Lord Nelson said that there was only five minutes difference in time between victory and defeat. Captain Rivet says with fast ships, such as are used nowadays, for "five minutes" read "five seconds."

A great variety of opinion exists on the question whether vessels will ram each other *head on*. Many good commanding officers say that they would not hesitate to meet their antagonists in this way; in fact their decision is supported by the latest writers. As far back as ten years, Captain Noel said:

> If an enemy is observed to be approaching from ahead it seems to me that the only chance of frustrating his attack is to keep your bow exactly on his, and so meet him.

There are, however, many others who say that such an action could only result in mutual disaster, and that it should never be resorted to.

In ramming, mechanical handling of the rudder, either by steam or hydraulic power, is an absolute necessity. The engines should be stopped before actual contact is made, and therefore the ship should be fitted with engines, boilers, and pipe connections properly stayed and arranged to ram an enemy, or to withstand a ramming, without giving way.

If your ship is a ram, and you are chasing an enemy, and you have superior speed, do not keep in his wake, as you might run on top of a torpedo which he has thrown overboard. Keep a little on his quarter, and as you draw *well up* on his broadside sheer in to him as normally as you can, trying to destroy his screw and rudder. This is a good maxim. (See Plate VI, Fig. 1.)

Since an engagement between two vessels is very likely to degenerate into an artillery duel, each moving in the same direction around the circumference of a common circle, each vessel should look out for torpedoes dropped in the wake by the other.

If two ships intend to ram, and collide broadside to broadside at *C* (see Plate VI, Fig. 2), and the A puts his helm hard aport and B his hard astarboard, the ships will meet again at C′ and again at C. If, however, B's turning circle is smaller than A's in diameter, at C′, B will be inside of A's circle and safe from ramming at C″. If the two vessels put their helms each the same way when they collide, they will each describe a circle and meet again at C.

If the two vessels are steering around the same circle the faster vessel may ram the slower in the stern. (See Plate VI, Fig. 3.) Or if one vessel has greater facility of maneuvering, as, for instance, a smaller turning circle, she can ram the other on the quarter by steering a course within the other's circle. (See Plate VI, Fig. 4.)

When one vessel is attacked by two she should never enter upon circling, as one of the vessels could enter the lists with her and the other could stand aloof and ram when an opportunity offered.

IV.

Automobile torpedoes can be installed so as to sweep from right ahead to right astern, according as they are put in the bow, broadside, or stern. A broadside installation, however, alone permits of any horizontal train. At present, in the French service, the torpedo is discharged above water. If they are discharged ahead, the pitching of the ship disturbs the depth of immersion for some time in their flight.

Discharged from the side in even a moderately heavy sea, if the bow of the torpedo strikes a wave, the torpedo will probably be altered in its flight laterally. Discharged from the stern, the torpedo is acted upon by the water stirred up by the screw. It is believed that an installation right ahead is the best for torpedoes, as it takes up less of the attention of the captain in using them. The captain already has too much to look out for in battle.

In discharging automobile torpedoes from the bow, we will consider the tube as being fixed in a fore-and-aft line. Launching in this direction can be considered as extending the ram of the vessel some hundred yards, as the torpedo during its flight can be counted upon to go in the direction of the ship's head. There are no doubt times during an engagement when a torpedo can be fired from this position with great success. It has this drawback, however, in a stern chase a slight error in the pointing of the head of the ship will make the torpedo miss the object fired at. Added to this there is the possibility of running over your own torpedo. This latter danger can of course be avoided by having the torpedo sink at the end of its flight.

The best way to show the relation that should exist between the attempt to use the torpedo and how to avoid it, is by tracing the movements of the two ships. The question will be considered in three categories.

1. The course of A crosses the course of B, who for some reason does not change it, but continues on.

2. The courses of the two ships are parallel and opposite. The attack is made by a rapid sheer of one of the ships towards the other.

3. The enemy strives to avoid the attack by turning with his helm hard over.

First Case. *When the two paths cross.* (See Plate VI, Fig. 5.)—A has the greatest speed and intends to attack. If A is at *A* and B at *B*, A should ram B at *A′* (B then being at *B′*). Since the torpedo is in the fore-and-aft line of the ship, A would have to turn towards *B* to discharge it. This A could not do and be certain to ram B at *B′*. The torpedo then could not be used except just before contact. It may be well to state here how A should steer with reference to B in order to ram him. A knowing both ship's speeds, should keep a bearing on B.'s stern *and not change* it. If A's speed is half again as great as B's, he should keep B four points on his bow; but as it is likely to be only one-tenth more, he should then keep B about a point or a point and a half forward of his (A's) beam. (See Plate VI, Fig. 5.)

Suppose, however, that A wishes to torpedo B. Since his torpedo travels at a speed of 20 knots, and is available within 350 yards, he can, when at a determinate point, *A′* (see Plate VII, Fig. 1), swing through the calculated angle and discharge his torpedo; then he could swing back again and head for the point where he knows that he can ram B, or if he fails in reaching B can pass under his stern and give him a broadside. In the figure, A at *A* gets a line of bearing *AB* on B at *B* At *A′* A swings through the proper arc and discharges his torpedo, B being at *B′*, the torpedo and B should meet at *x*. B, if he escapes the torpedo, might be rammed by A at *B″*, A being then at *A″*. If, however, B has arrived at *B‴*, A cannot ram him, but must pass under B's stern.

SECOND CASE. *Courses parallel and opposite.*—A and B are passing on parallel courses 350 yards apart. (See Plate VII, Fig. 2.) A, wishing to ram B, puts his helm hard a starboard and sheers to port. He will ram B at x, but A cannot use his torpedo. B at B', however, bears slightly to port and can use his torpedo on A, who will be at A', hitting A at y.

THIRD CASE. *Two vessels maneuver each to ram the other.*—A, having greater speed than B, could get within B's turning circle, and so have him at a disadvantage. (See Plate VII, Fig. 3.) A could use his torpedo at A', B being at B', which would strike B at x. A can continue on and ram B at B'' or can pass astern of B, and give him a broadside. This case is an illustration of the maxim that, all else being equal, the advantage remains with the ship having the greatest speed.

In case the torpedo is installed astern the best time to use it is when the vessel, having missed ramming you, passes under your stern. Or should two vessels be passing on opposite courses, B turns across A's stern. A would stop and fire his torpedo with his head pointing in such a direction that it will reach B at B'. (See Plate VIII, Fig. 1.) Then shifting his helm in the same direction as B, he starts ahead at full speed and continues his circle. There is really no good reason why he should continue to turn beyond a, unless he has greater speed than B, as when he is at a B is at b, and any further turn brings A within B's turning circle and puts him at a disadvantage as regards B.

Should the torpedo be installed in the side, the instant of discharge will depend upon the speed of the two ships. It is of great importance to discharge your torpedo so as to strike your adversary before he can fire his concentrated broadside. The exact place of installation is really of great moment, especially for distances close aboard. Probably the best in broadside is as far aft as possible, as the great point is to have a torpedo ready to prevent the enemy ramming you, which he will try to do on the quarter. The discharging tube should admit of a train three points forward of the been.

As an example of when the broadside installation is of greatest use, we suppose two vessels to steer courses that intersect, the slower one can use his torpedoes on the faster at any time that the ships are within 350 yards of each other. In this case, also, the best point of installation would be as far aft as possible, as the slower vessel could always turn from the faster vessel and have him in range as regards his torpedo. (See Plate VII, Fig. 4.)

V.

SINGLE COMBAT.—The broadside fire is no longer the principal and only power of attack; still a fight will be opened by artillery, although the ultimate design will unquestionably be to ram. The whole point to strive for will be a commanding position—a position of advantage—using the guns to overcome the enemy, or torpedo if possible, and the ram to give the *coup de grâce.*

We will suppose two rams identical in qualifications are pitted against one another. There will be some evolutionary sparring, a feeling of one another, and then an arrival at one of the following positions referred to shortly.

Admiral Randolph, from whose work on Naval Tactics the following cases are taken, does not believe that rams will meet each other head on. He thinks that they will pass in opposite directions close aboard, exchanging broadsides. (See Plate VIII, Fig. 2.)

As they pass, A might turn with the utmost rapidity with his helm hard aport across B's stern. If B at the same instant puts his helm hard a-starboard, A at A_2 would have the power of passing ahead of B, who would then be at B_2. A might then *stop* inside of B's circle; or, if B continued to circle, A might ram B at x.

All else being equal, the one which uses her helm quickest would get to a *safety point* inside the other's turning circle. If B, however, after passing astern of A at A_2 (B_2) were to slow also, and they were to be in the position shown in Plate VIII, Fig. 3, then each could be said to be inside the circle of the other, and the one which can by means of fore-and-aft sails, drags, or sternway get its head pointed fair at its opponent, has the position of advantage and can ram. It follows then as a maxim that the ship which first passes into the circle of the other has the advantage.

Having examined the engagement from a ramming stand-point, we will now consider it from an artillery view.

Broadsides have been fired when the vessels were abreast one another on opposite parallel courses. At A_2, A fires his other broadside, B being at B_2, the ships being at close quarters. Instead of crossing B's bows, A might be able to go astern of B. He might or might not be able to give B a broadside, as that would depend upon whether he had had time to reload his battery.

If, after the exchange of the first broadsides, each ship turned across the other's stern the result would be separation for more than two diameters of their circles, and a renewed meeting end on.

If, instead of commencing the duel by exchanging broadsides, suppose one of the ships endeavors to obtain by maneuvering some opening advantage, and for this purpose when 1,000 yards off turns quickly in one direction in the hope that the enemy will turn towards him in the same direction, and instantly, after he has turned through 4 points, rights and shifts his helm, and, supposing his maneuver has induced the enemy to circle, runs astern of his opponent, giving him a broadside in passing, and immediately slows, he will then have the advantage of having made the enemy feel his metal and will be inside his enemy's circle, comparatively safe, and ready to ram. (See Plate VIII, Fig. 4.) A yaws, and straightens up at A_b. B, misled, turns and receives a broad side from A, when A is at A_2 and B is at B_2. Finally A, at A_3, is slowed and inside of B's turning circle.

If B does not change his course at B, but stands on, he will give A a broadside at B_b, A being then at A_b; then, if A turns astern of B, he can finally get inside of B's turning circle at A_a, but he will have received B's other broadside when he is at B_c and A at A_c, but the distance will be comparatively great. (See same plate and figure.) If the ships have strong bow-fire this must be taken into consideration.

Still other tactics. (See Plate IX, Fig. 1.)—B may wish to try his artillery first, and so alters course 5½ points to port. A steers toward him, and, if speeds were equal, there would be a collision at x. After exchanging fire for some time, one or the other wishing to continue to use artillery must keep away, which would finally end in a stern chase, either straight away or both ships steering around a circle. If this is not the case, and they both steer to meet until their tactical circles intersect, and both put their helms over simultaneously so as to turn towards one another, they would meet bow and bow, without advantage being to either. Here the faster ship might by a sheer pass astern of the other, say A astern of B, and getting inside the other's circle have the advantage; or, again, if they were very near and both had the same speed one might slow for an instant and be able to ram the other. Say B to ram A. (See Plate IX, Fig. 2.)

Captain Colomb, R. N., in his work "On the attack and defense of fleets," says it is a mistake generally made that vessels desirous of ramming one another will head directly for one another. On the contrary, a vessel should keep the enemy on his bow, and put his helm over to ram when the opposing vessel is a little less than 4 points on his bow and 200 yards away. If he does so he will strike the other vessel at right angles to his course. This supposes a speed of about 10 knots.

Vice-Admiral Bourgois, M. F., says, in speaking of single combats between armored vessels, suppose two adversaries, steering straight courses that intersect, are led to fall foul of one another. The probabilities are that they will come together, scraping broadside to broadside, end for end. If they are equal in speed and tactical qualities each vessel should come around under the stern of the other. If they are unequal the vessel that has the *greater speed* should put her helm over the *same* way as her adversary. Again, the vessel that *turns in the smaller circle* should put her helm the *opposite* way from her adversary. To illustrate: If B has greater speed than A (see Plate IX, Fig. 3), when A is at A', B will be at B', and in a better position to ram than would A; or B can run inside of A's circle and be on a safety point at B''. But if A's turning circle is smaller than B's, by A putting his helm as directed he has the advantage at A' over B at B'. (See Plate IX, Fig. 4.)

Captain Fremantle, R. N., discussing the subject of single combat, supposes the antagonists to be equal in power and in all tactical qualities. He says: "Our tactics are ramming tactics, and the enemy is ready to meet us on our own ground." (See Plate IX, Fig. 6.)

A steers for the enemy B, keeping him a couple of points on the bow. They are 2,000 yards apart. A intends to ram from the first, while B's plan is not yet matured, but intends to use his guns and to ram A the first time he makes a broad sheer. B is willing to keep A on his bow for this reason. They near one another, steering opposite and parallel courses. Both going at full speed, they should meet in three minutes. Each keeps the other from 1½ to 2 points open on the bow. A intends to fire one round from his bow gun and then ram. The gun is kept on the enemy and laid for 900 yards. The instant B's masthead angle shows that the vessels are separated that distance, A fires and puts his helm hard aport. The smoke hides A for half a minute. If B stands on for that length of time A will ram B probably effectually. If, when A fires his gun, B shows for an instant and starts ahead again, B would probably ram A.

Captain Colomb says, very truly, that the difference between ramming and being rammed lies in "half a ship's length."

Should B be wary and keep always head on to A they would of course meet, but Captain Fremantle, although not believing that vessels will intentionally ram one another head on, thinks that vessels will go so close as to collide broadside to broadside, thus agreeing with Vice-Admiral Bourgois: "Here would be a chance for a skillful captain to injure the enemy's steering-gear and screw by a double movement of the helm."

Supposing A and B to be broadside and broadside, and each ship going at full speed, with A's helm hard astarboard and B's helm hard aport, each would describe a circle, with the chances in favor of A, since A would be inside of B's circle and would have another chance to ram.

If from the position of broadside to broadside each ship went ahead at full speed, with helms hard astarboard, then the conditions would be the same as when they bore down for each other at the first.

Should they agree to fight an artillery and torpedo duel after ineffectual ramming they would probably ultimately find themselves moving about each other around the circumference of a circle of 400 or 500 yards in diameter. Once in this position neither could use his ram except by stopping or going astern, which would be extremely dangerous. In these duels of the ram, gun, or torpedo, success should lie with the fastest ship, other things being equal.

Lieutenant Bethell, in his work on two vessels in action, discusses the most advantageous maneuvers that can take take place between two adversaries in single combat. He draws attention to the environment of one position, which he calls the "position of greatest danger," and gives rules to follow to avoid it, and he further shows the importance of turning power in a vessel. We propose now to take up the different cases which present themselves, and to examine into the position of greatest danger.

We consider two vessels, A and B, of equal tactical value, and it is to be shown that one of them can, to a greater degree or lesser degree, force the other to assume a disadvantageous position, and that this locality may be termed the "danger-field." To escape from this environment requires certain tactics, which if not adopted, put the threatened vessel in a constantly increasing position of danger, until she arrives at a point called the "position of greatest danger," where her destruction is imminent. (See Plate IX, Fig. 5.)

A is in this position as regards B: If A attempts to turn in order to put himself on equal terms with B, B will ram him. A can only use a weak stern fire on B. B can keep up a powerful bow fire on A. A has one advantage alone over B; he can use his torpedoes better.

The *danger field* is the forward half of A's turning circle on either side if A and B bear relatively as in the diagram. In order that A shall clear the danger field and meet B on equal terms, the time that it takes him to turn through the first two quadrants must be less than the time it would take for B to get to him. The necessary distance can be determined by A measuring B's masthead angle.

A can hardly escape, when having swung through, say, the first quadrant, he runs off at right angles to his first course, for his pursuer having only to move on the circumference of a larger circle has had his speed but little reduced, and therefore arrives in A's wake nearer to him than on the last course. In other words, unless A can shake B off by superior speed, he only *helps* him by turning. (See Plate X, Fig. 1.)

In a ramming duel, then, one vessel will try to force the other into the danger field, and to the position of greatest danger in that field; and the question arises how to avoid it for one, and how to force it on the other. If two vessels are maneuvering, and one is unable to approach the other, the one has the advantage if he can get in the wake of the other within 400 yards. The pursued is, of course, safe as long as he steers a direct course, but if he attempts to maneuver, he shortens the distance between himself and the pursuer. By the pursued having the advantage, is meant that the natural impulse of the pursued is to fight, and the instant he turns he comes in the danger field. (See Plate X, Fig. 2.)

Another phase of this example: Suppose A wishes to close with B. If he can force B into his wake at a distance that would take B longer to traverse than it would A to turn her bow to B, then A could effect his object, or if B continued to stand on and not turn A would have B in her danger field. (See Plate X, Fig. 3.)

We will now consider an engagement between two vessels equal in all respects, and steaming at a rate of 12 knots. Each vessel has a diameter of turning circle of 500 yards which she executes in five minutes.

The following formula seems to express what is incontrovertibly a fact:

If one vessel is turning, and another enters his circle, then, if the latter vessel enters on an opposite course to that of the turning vessel at the moment of entry, or is permitted to come to an opposite course while inside the circle, the turning vessel is momentarily on equal terms with the other, and has the power of retaining that equality by a proper use of the helm.

CASE I.—A and B are passing 150 yards apart, steering opposite and parallel courses. Each puts its helm over the same way, at the same instant, so as to cross the other's wake. Result: They will come around and be on equal terms. (See Plate X, Fig. 4.)

CASE II.—But if the helms are put different ways, say, A's to port, and B's to starboard (see Plate X, Fig. 5), B will enter A's circle at B′ while A is at A′. B will have the advantage, being inside of A's circle, and safe from A's ram, while B can use his. A should not attempt to turn this way unless the perpendicular distance *A B*, was so great as to permit A to turn more than 16 points before B can enter his circle. In this case he would be on equal terms with B.

CASE III.—Suppose A, instead of putting his helm either way, when B began his circle, continued to stand on for one minute, and then put his helm over, he would find that no matter which way he turned, he could turn through more than 16 points, and could therefore meet B on equal terms; for when he arrived at y or y' B would be at x or x'. (See Plate XI, Fig. 1.)

It follows from these considerations that if two equal vessels are passing one another close to, and maintaining the same speed it is immaterial, so far as gaining tactical advantage is concerned, *when* they elect to turn, with the exception of Case II, already discussed.

Now, as regards artillery, the two vessels will exchange broadsides in passing, but if A stands on, B has the advantage, as he can give A a broadside at b or b', when A can only reply with a weak stern fire, being then at A' or A'' or A'''.

Taking everything into consideration, however, we may lay down the rule that two vessels passing, apart from unforeseen circumstances, it is best for them not to delay turning.

If two vessels are separated in passing the diameter of a turning circle no tactical advantage can be gained by either turning. This is equally true if either stand on and elect to turn at a later time. It will be seen, then, that although it is better to turn immediately on passing your opponent, so as to get the advantage of fire, it is not vitally bad tactics to delay doing so.

We come now to consider two vessels that are *unequal* either in *speed* or *turning power*.

I. If two vessels engage, and instead of being equal in all respects, have unequal speeds, then the slower of the two could not delay her turn, after her adversary had begun to turn, without losing her position of equality. Conversely the faster of the two can turn when she wishes without sacrificing her advantage.

II. If two vessels engage, and instead of being equal in all respects one has greater facility of turning than the other, the one which has the smaller diameter of circle should turn immediately, as in one minute, with a speed even of 12 knots, her advantage has disappeared, if we suppose that her adversary had turned when she did and across her stern.

III. But if this latter vessel, with the larger turning circle, does not turn until later, and the one with the smaller circle turns immediately, there will be no advantage of position for either vessel.

IV. If two vessels engage, and one turns quicker than the other, then the one with the smaller circle increases her advantage for every increase of distance from her adversary, when abreast one another, until such distance is equal to the diameter of the smaller turning circle, when the quicker turning ship is at the position of greatest advantage, *provided* that her adversary crosses her wake in turning. If, however, her opponent turns from her she loses *part* of her advantage of position. (See Plate XI, Fig. 2.)

Therefore, not knowing which way the adversary will turn, the quicker turning vessel should seek to pass close to the other, so as not to risk losing any advantage. To illustrate: Let A in the diagram be the vessel with the smaller circle. If A and B cross each other's wake, A will enter B's circle at about *a*, and have the advantage, B being then at *b*. If we suppose A and B to be apart a distance equal to A's diameter of circle, that is, for A to be at *A′*, we will see that the position is still more advantageous for A, since when B is at *b* A will be at *a′*. If, however, B turns the other way he will be at *b′* when A is at *a″* or *a‴*, and A will therefore have less advantage if he started from *A′* than if he started from *A*. It will be noticed that the quicker turning vessel has the advantage, from an artillery stand-point, all through.

We come now to consider *slower speed* balanced by *greater turning power*.

A has 12 knots speed; large turning circle, taking five minutes to complete.

B has 10 knots speed; small turning circle, taking three minutes to complete. (See Plate XI, Fig. 3.)

I. If both ships are in the usual position of passing close to on opposite and parallel courses, and both turn with the helm the same way and at the same instant, B will be able to get A in the danger-field; but probably before B can traverse the distance between them A will have turned through enough points to be on an equality with B as regards tactical position. B, however, will give A two broadsides for one that he receives.

II. If B stands on, even for one minute, he loses any possible advantage he might have reaped by an immediate turn. Conversely, if A stands on for one minute or longer he will be clear of any possible danger from B's ram. Here, if B turns at *B* he will be at *b* when A is at *a*, but A, being faster, *might* put himself on an equality before B traverses the intervening distance.

If B stands on to *B′* before he turns, he will be at *b′*, when A is at *a*.

If A stands on to *A′* before turning, neither will have an advantage.

III. If B is pursued on a straight line by A, A having the speed can in time overtake him. B turns to put himself on an equality with A. If A can traverse the distance before B can turn through 16 points, he can ram B, so that B notwithstanding his turning power must succumb to A, or turn before A gets within 600 yards of him.

IV. B must at all times endeavor to turn with his helm the opposite way from A, when both turn on passing; for the reason, by so doing he gets inside of A's turning circle, where the poor quality of his speed is least felt.

V. Should A pass B going in the same direction, B should try and force him to turn, by feinting a ramming attack, and thereby put A in the danger-field by entering his turning circle. (See Plate XI, Fig. 4.)

For an actual fact, it would be very bad tactics for A. to take any position forward of four points on B's quarter. His best position would be astern of B, and out of B's wake.

Slow ships therefore should have heavy stern fire.

With *twin screws* the turning circle becomes smaller, and therefore the advantage for B greater. A, the faster, should avoid turning until two or three minutes after B, and should always put his helm the *same way* that B has his.

Lieutenant Bethell is of the opinion, since rank turning with twin screws represents a position of almost absolute rest, vessels should avoid the excessive use of the maneuvering quality of their screws, as the destruction of momentum is an advantage thrown away.

Lieutenant de Vaisseau Besson, of the French Navy, in discussing the subject of an engagement between two vessels, equal in all tactical respects, formulates the conditions in thirteen theorems. Some of these have already been considered and some are sufficiently evident from an inspection of the diagrams. Others will be explained.

THEOREM 1. When two rams are in action, the first that enters the turning circle of the other has the advantage. He can ram the other or force him to run. (See Plate XI, Fig. 5.) A entering B's circle can ram B. B cannot ram A at any point, as A is always in B's circle. B to avoid being rammed must run.

THEOREM 2. When a vessel enters the turning circle of another, in order to ram, it is necessary that the assailant shall head within an angle formed by a line which joins the two ships, and a tangent to the turning circle of the adversary at the point of entrance. (See Plate XII, Fig. 1)

It will be seen that B enters A's circle at B. The distance CB is equal AC, and from the fact that the figure $oCo'B$ is a lozenge, the angles o and o' are equal; more than that, oC being parallel to $o'B$, is perpendicular to AB, tangent to B for the circle o'. From these facts we conclude that the arcs AC and CnB are each equal to arc CmB, and are consequently equal to each other. The two ships describing routes of equal length, the collision will take place at C, to the advantage of B, he slightly diminishing his speed to let A reach A slightly ahead.

To the extent that B has his head to the right of the line AB, just so much smaller will be the arc that he will have to traverse to ram A; of course diminishing his speed to do this. He cannot be rammed by A, since he is in A's circle. The limit of B's advantage is when his head is in the line BD, when the two ships, turning in opposite directions on the same circle, and will meet head on at C. Should B's head lie to the left of the line $A\ B$, she will be inside A's turning circle and safe from A's ram, but he cannot ram A, as he will have to traverse a longer path than A to meet on A's turning circle, which he cannot do, since their speeds are taken as equal. If B's head lies to the right of the line $B\ D$ he will have A in his turning circle and the case is reversed.

THEOREM 3.—When a vessel, entering the turning circle of another, has her head towards her adversary, and succeeds in ramming him, the angle of contact is equal to the angle of the initial routes. (See Plate XII, Fig. 2.)

The initial route is the relative bearing of B from A, or the angle included between their courses, or the angle $B\,A\,E$ in the figure. To show that $B\,A\,E = H\,C\,K$.

$$\text{The initial route } B\,A\,E = 90° - o\,A\,G$$
$$\text{The angle of contact } H\,C\,K = 90° - o\,C\,H.$$

The triangles $o\,B\,G$, $o\,A\,G$, $o\,H\,C$, are equal; so also the angles $o\,A\,G$ and $o\,C\,H$, consequently $G\,A\,E = H\,C\,K$. The best way therefore to enter your adversary's circle is to have your bow on his middle point, and at the same time on the center of his circle. The adversary then is crossing your bows, and the angle of contact will be a right-angle.

THEOREM 4.—If two ships are too near to run directly at one another, and are steering convergent courses, the advantage, at any instant, is with the one which has the other bearing more on its bow. (See Plate XII, Fig. 3.)

In the figure, A having B bearing more on its bow, has the advantage from a ramming point of view. They are too near to suppose that B, having a shorter distance to traverse to reach the intersection, will attempt to run ahead of A.

THEOREM 5.—The advantage of bearing is greater, the nearer two vessels are together; it ceases when their distance is greater than five times the radius of their turning circles. (See Plate XII, Fig. 4.)

The demonstration of the part of this theorem is evident. B has the best chance to ram A at *B*, and less chance to ram A as he recedes towards *B′*, *B″*, since B has a longer distance to go over. It will be seen by Plate XII, Fig. 5, that A and B are six radii apart. B is in a position most favorable to ram, and A is in the most unfavorable position for being rammed. But A can turn through sixteen points and be in a position of equality with B before B can reach her.

THEOREM 6. (This theorem refers only to the rules of the road and has no war value.)

THEOREM 7.—When two rams pass broadside to broadside each should turn towards the other in describing their circles (*i. e.*, cross each other's wake) when they will meet again under the same circumstances. If they each turn with their helms the same way the one that is turned *towards* is at a disadvantage.

THEOREM 8.—In passing broadside to broadside the maneuver to turn under the stern of the other, should be commenced as soon as possible.

THEOREM 9.—When two ships are together broadside and broadside, if they have the same diameter of turning circle, the advantage will belong to the one who is the fastest, that is to say, to the one who describes his circle in the least time.

THEOREM 10.—Two vessels close to, and broadside to broadside, having turning-circles of different diameters, but whose circles are made in the same time, the advantage will belong to the one that has the smaller circle.

THEOREM 11.—When two rams are close to, and broadside to broadside, and on opposite courses; one turning quicker from greater speed, and the other having a smaller diameter of circle, the advantage will belong to the one with the greater speed, if each turns under the stern of the other, and to the one with the smaller circle if they turn with their helms different ways.

THEOREM 12.—Two ships passing broadside to broadside, on opposite and parallel courses, and close to, describing with helms in the same direction like turns, there exists a point which does not change, and which is the only point where they can meet. (This point is hard to determine, and the demonstration is not here entered into.)

THEOREM 13.—The quickest method of approaching another ship is to keep your bow pointed towards him.

VI.

In the action between the Esmeralda and the Huascar, and the Independencia and the Covadonga, in the Chile-Peruvian war, although nothing new in the way of naval tactics was developed, still the weaker vessels were handled with great *strategical* skill by their captains, who no doubt would have shown, had their commands been equal in any way to those of their antagonists, an intimate knowledge of the maneuvering of vessels, and the employment of their tactical qualities in an engagement, which indeed might have taught us some new lessons in this science, as brilliant perhaps as were the records of these officers for nerve, daring, and pluck. Lieut. T. B. M. Mason, United States Navy, tells the story as follows:

During the night of May 20–21 the Huascar,* Captain Grau, senior officer, and the Independencia,† Capt. J. G. Moore, touched at Pisagua to make sure of the absence of the Chilian iron-clads. Being reassured, they continued on, and at daylight on the morning of the 21st, were seen approaching Iquiqui.

As soon as Commander Arturo Prat, senior officer, commanding the Esmeralda,‡ made out the enemy, he signaled to Commander Carlos Condell, commanding the Covadonga, to take position in his wake, and these two small vessels prepared for action. It was doubtless the purpose of Prat, from the first, to fight, though the disparity of force was so great. He could not escape on account of his low speed, but he would not have been much blamed by the world at large if he had destroyed his ships, surrendering himself and his crews, or if after a few shots he had surrendered all. But Prat was not the man to take advantage of either of these methods of saving life.

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*The iron-clad single-turret ram Huascar: length, 196 feet; beam, 35 feet 6 inches; depth of hold, 21 feet; free-board, 4 feet 6 inches; draught forward, 15 feet—aft, 16 feet; displacement, 1,130 tons; indicated horse-power, 1,200; coal capacity, 300 tons; turning capacity, through 180°, 2 minutes 0.3 seconds; maximum speed, 11 knots. Armament: Two 10-inch 12½ ton 300-pounder muzzle-loading Armstrong rifles, mounted in a revolving turret, placed forward. This turret is on Captain Coles's plan, being supported on rollers, and revolved by hand-gearing. The exterior diameter is 22 feet. Owing to a top-gallant forecastle forward, and the conning tower and stationary bulwarks aft, the turret guns command only 138° of the horizon; that is, from 10° on either side of the bow-line to 32° on either side of the stern line. Two 40-pounder muzzle-loading Armstrong rifles, one on the starboard quarter-deck and one in the stern; one 12-pounder muzzle loading Armstrong on the port quarter deck. These light guns are all mounted on wooden Marsilly carriages. Armor: The side armor, extending 3 feet 6 inches below the load-water line, has a thickness of 4½ inches abreast the turret chamber, fire and engine rooms, diminishing to 2½ inches at the bow and stern. This is backed by 10 inches of teak and an inner iron skin ½-inch thick. The bow is re-enforced and shaped for ramming. The decks are protected by 2-inch plates. The spar-deck terminates forward in a small top-gallant forecastle, about 6 feet high, on which the anchors are secured, and in an open poop aft.

†The iron-clad ram frigate Independencia, built by Samuda, at Poplar on Thames, England, in 1864. Hull, iron; displacement, 2,004 tons; machinery by John Penn & Sons, old type; indicated horse-power, 1,500; maximum speed on trial, April 27, 1879, 12 knots; coal capacity, 400 tons; armament, two 150-pounder muzzle-loading Armstrong rifles on spar-deck pivots; twelve 70-pounder muzzle-loading Armstrong rifles in broadside, on a clear gun-deck. To this, at the outbreak of the war, were added one 250-pounder muzzle-loading Vavasseur rifle on pivot in bows; one 150-pounder muzzle-loading Parrott rifle on pivot in stern. Armor, 4½ inches thick at water-line, and about central part of battery, backed by 10 inches of teak. Bow strengthened and shaped for ramming. Condition: hull good; boilers new. Rig, ship.

‡The sloop of war Esmeralda, built in England in 1854. Hull, wood; length between perpendiculars, 200 feet; beam, 35 feet; draught, 14 feet; tonnage, old measurement, 850 tons; engines, simple, old type; nominal horse-power, 200; screw, single and lifting; speed, 3 knots; rig, ship; armament: original, eight 40-pounder muzzle-loading Armstrong rifles, in broadside, increased to fourteen 40-pounder muzzle-loading Armstrong rifles, broadside; crew, 160 men; condition of hull, old and rotten; boilers, very old and almost unserviceable.

Born April 3, 1848, he was still a very young commander. He had been a marked man in his service, having held positions of the greatest trust; by his conduct in the capture of the Covadonga and in quelling a serious mutiny on board the Peruvian corvette Union he had gained a reputation for gallantry; by being selected more than once as an instructor in gunnery at the naval school he had proved his theoretical proficiency in that all-important branch of study. Was this young senior officer fitted by his antecedents to surrender? The answer to this question is his conduct in the engagement which was about to take place—a fight that astonished the naval world; which established the precedent that, no matter what the odds be, vessels must be fought to the last, and which, on account of the intelligence and intrepidity that characterized it, and on account of the harm that was actually done to the powerful opponent, deserves a whole page in the records of fame.

It was a curious combination of circumstances that brought Grau and Prat together in deadly combat, both to die, sword in hand, in the heat of combat, within a few feet of the same spot on the deck of the Huascar, each being at the time of his death the senior officer of an immensely inferior force contending nobly against great odds.

At 8 a. m. the Huascar fired a shot that struck between the two Chilian vessels, and the action immediately became general; the Huascar singling out the Esmeralda, and the Independencia the Covadonga. The Chilian transport Lamar, which was also in port when the enemy was sighted, was sent off to the southward and took no part in the fight. After the firing had been going on for an hour, at distances varying from 2,000 yards to, perhaps, 1,000, the Covadonga steered to the south, the Independencia following her closely.

The Esmeralda remained in Iquiqui Harbor, fighting the Huascar. By this time the Peruvian soldiers had dragged a field battery to the beach, and opened fire at distances not exceeding 400 or 500 yards. Thus, with the 300-pounders of the Huascar on one side, and a field battery on the other, the Esmeralda was forced to abandon her position near the shore, which she had taken to avoid a ram attack from the enemy, and go farther out in the bay. The time when this occurred, and that at which the Huascar first rammed, has not been fixed satisfactorily; but it could not have been far from half past ten, two hours and a half after the beginning of the fight. It appears that Captain Grau was deterred from ramming by the fear of torpedoes, which he supposed were placed around the Esmeralda; and he rammed only when the latter vessel was driven from the place which she had first occupied, by the fire of the field battery on shore. The defense of the Chilian vessel would have lasted a much longer time if the fight had been decided entirely by the guns. The Huascar kept up a fire from all her guns for four hours, and during this time must have fired at least forty shots from her two 300-pounders; yet it is recorded that only one of these shots struck the enemy. This shot passed through the side, burst in the engine-room, and killed every one of the engineers, besides disabling the engine. The reply of the Esmeralda was most effective, as is testified by Captain Grau; but musketry and 40-pound shot are no match for 7-inch armor. Captain Grau is in error when he speaks of the mitrailleuse fire of the Chilians, in his report; neither the Esmeralda nor the Covadonga had machine guns of any kind. The Huascar had one long Gatling.

When the Esmeralda came out in the bay Captain Grau determined to ram her. In the first attempt, the Huascar, steaming about 8 knots and steering NE., struck the Esmeralda, nearly motionless and heading N., on the port quarter. The Huascar's engine was stopped when she was about one ship's length from her adversary. The blow was harmless. Captain Prat, followed by one man only, gallantly sprang on the forcastle, and, sword in hand, rushed aft on the port side of the deck, and was killed by a musket-ball at the foot of the turret. The command now devolved on Lieutenant Serrano. The Huascar backed off and made at the Esmeralda again, this time heading S.; the Chilian vessel presented her bow: the Huascar's engines were stopped too soon, and she struck the starboard bow of the enemy, doing little or no damage. Again a boarding party, headed by the commanding officer, Lieutenant Serrano, leaped on the Huascar's deck, but only to be shot down. The third attempt of the Huascar was better conducted. The head of the Chilian vessel had fallen off to W., and Captain Grau, steering S., going full speed, and stopping his engines when 20 feet from the Esmeralda, struck his adversary squarely on the starboard beam. The Esmeralda sank with her colors flying and guns firing.

The Covadonga,* meanwhile, was doing all that seamanship and courage could dictate to get away from her huge pursuer. She led along close to the shore, crossing shoal places, and actually, at times, almost in the breakers. The Independencia, with her raw, unskilled gunners, could not hit the little craft, though the vessels must have been within 200 yards of each other several times. Captain Moore, fearing that he could never end the affair with his guns, determined to ram; this he tried three times, and failed to accomplish. The third attempt was made at Punta Grueso, at a time when the Covadonga was not 100 yards from the beach and had actually touched on the reef. Steering about S.SE., the Independencia aimed an oblique blow at the Covadonga's starboard quarter, and, missing her enemy, struck a rock and stuck fast. It appears from the reports of both captains, Moore and Condell, that the helm of the Peruvian ship was not ported early enough to prevent her going ashore, because a shot from one of the Covadonga's 70-pounders killed her helmsman. The only steering-wheel of the Independencia was the ordinary one on deck.

It must have been 11.45 a. m. when the Independencia † struck. Captain Condell, seeing at once the state of affairs, turned his vessel, and, passing along the starboard side of the enemy, coolly took his position astern of him and began to fire. It has been asserted that the Independencia's ensign was hauled down and a flag of truce hoisted, on account of the deliberate fire of the enemy and her inability to return it, having fallen over on her starboard side, and her lower part having filled with water. To add to the discomfiture of those on board, a shell from the Covadonga, or an accident, set fire to the after part of the vessel.

Immediately after the surrender of the Independencia, and before she was taken possession of, the Huascar, which, having sunk the Esmeralda at 12.10 p. m., had remained to pick up the survivors of her crew, came around the western end of the island which forms the south side of Iquiqui Bay. She was about 10 miles off, and the Covadonga, having evidently disposed of the Independencia, was steaming rapidly away. The Huascar, after speaking her stranded consort to ascertain whether there was any immediate danger to the life of the crew, resumed her pursuit of the Covadonga. This pursuit lasted until dark, when Captain Grau, seeing that there were still 10 miles between him and the chase, and probably uneasy about the enemy's iron-clad's, whose position was unknown to him, gave up the pursuit and returned to the Independencia. This vessel it was clearly impossible to save, and she was set on fire and burned.

Nothing could have been better than Prat's plan of action. First remaining stationary in a corner between the island and the shore, he limited the field of his adversary's maneuvers to ram, conveying also the idea that he was protected by those terrors of modern naval warfare, torpedoes. This impression was rendered doubly certain in Captain Grau's mind by the report of the Peruvian captain of the port of Iquiqui, who managed to get aboard the Huascar in his boat. Again, by assuming this position, he reduced Grau to the painful necessity of sending his shell, at moderately short range, directly towards the town which was occupied by his own country-men. When forced by the fire of the shore guns, more dangerous, at that short range, against his wooden walls than the 300-pounders of the iron-clad, he hugged the shore as closely as possible, keeping up a heavy, well-directed fire from his guns of all kinds, how well directed the condition of the Huascar after the fight clearly showed. One shot entered the turret through one of its ports, and after balloting about considerably, came to rest without injuring any one. Had this been a shell it might have entailed considerable loss. Other shots cut the tripod foremast nearly away; so insecure did it become that Captain Grau feared that it would fall, in which case it would probably jam the turret. When the ramming began Prat called away his boarders, and, as already stated, actually succeeded, with one sergeant of marines, in reaching the enemy's deck. Had the contact been of longer duration he would have succeeded, probably, in transferring his crew to the decks of the Huascar with a very fair chance, according to Captain Grau himself, of capturing the vessel, as the crew was, with very few exceptions, very much demoralized. Serrano's attempt failed from the same cause. When the Huascar did finally succeed in sinking the Esmeralda, which was then little more than a stationary target, she injured her own bow so severely that extensive repairs were necessary. The musketry fire of the Esmeralda was so well sustained that it was thought that she was provided with machine guns.

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* The gunboat Covadonga, captured from the Spaniards in 1866 by the Esmeralda. Tonnage, old measurement, 412; engines, old style, 140 horse-power; single screw; maximum speed, 5 knots; rig, three-masted topsail schooner; condition, hull poor; engines and boilers poor; armament, two 70-pounder muzzle-loading Armstrong rifles, on pivot carriages.

† See note on page 72.

Condell could not have done better with his little ship. That he followed the correct tactics in keeping close to the shore was proved by the results. His artillery fire, which was continued throughout the chase, was so excellent that he dismounted the heavy bow pivot of the Independencia before it had succeeded in sending more than one shot into him. What the effect would have been if this had not occurred may be imagined from the fact that this shot entered the starboard quarter, raked the whole length of the ship, and passed out on the port bow. The other two guns, being protected by iron plating, continued to fire, with but moderate results, owing to the want of training of the guns' crews. The small-arm fire of the Covadonga kept the enemy's crew below and killed the three helmsmen at the critical moment, according to Captain Moore, who, like Captain Grau, mistook it for machine-gun fire.

It was thus that Captain Prat's speech made to his officers and crew before the fight was carried out in its fullest details. Had the results of the action been different it might have passed for bombast; as it is, it becomes a fitting text for the naval students of the future:

"Children, the odds are against us. Our flag has never been lowered in the presence of the enemy; I hope that it will not be to-day. As long as I live that flag shall fly in its place, and if I die my officers will know how to do their duty."

Captain Moore was placed under arrest and kept a close prisoner on the Moro at Arica. The two 150-pounders of the Independencia were afterwards raised by the Peruvians and taken to Iquiqui..

This action, of course, raised the blockade of Iquiqui, and about 4,000 troops, Bolivians and Peruvians, were thrown into the place, which was visited also by General Prado.

The Huascar was considerably injured in the action, her tripod mast was so much damaged that it had to be removed on her return to Callao, her bow leaked from broken plates, and her turret was slightly out of line. She continued her cruise, however, to the southward. At Antofagasta she exchanged shots with the Covadonga, that lay inside of the reef, and was supported by three 150-pounders mounted in sand batteries along the face of the town.

VII.

Two ships against one.—It may seem strange at first sight to suppose that now-a-days one vessel would attempt to cope with two nearly her size, but in reality the two ships must work together, and be at all times alive to succor one another to compel victory to rest with them; for the single ship might steer down on one of the two advancing against her, close together and in line abreast, and when at the proper distance put her helm over and ram one, giving the other a broadside. Now, if the one first headed for and to whom she gave her first broadside was to attempt to ram her assailant the chances are that she would run foul of her consort.

Admiral Randolph says the proper course for the two ships to pursue when the enemy's single ship is bearing down on them is to form on a line abreast, with one ship's stern in a line with the other ship's bow and two cables apart. They should endeavor to keep the single ship between them. The idea of the line of bearing is, not only are the two ships' gun-fire more effectively arranged, but in case the single ship essays to ram one of the two ships the other ship can put her helm over to ram the rammer, without anything like the same danger there would be in an exact line abreast of running into her consort. At least this is Admiral Randolph's opinion.

There are several other ways that the consorts might arrange themselves, as in line ahead, or one might keep out of the fight until the other two were engaged, either in an artillery duel or in a ramming contest, and then could enter the fight and help her friend.

If circumstances should serve, that is, if there was plenty of smoke, which interfered more with the two than it did with the single ship, it would be good tactics for the single ship if she could keep outside of the two—outflank them in other words—to give one a broadside in passing and sweeping up under the stern of the other enter her turning circle.

We will consider A the single ship, and B_1 and B_2 the consorts.

Plate XIII, Fig. 1, shows how A should act.

Plate XIII, Fig. 2, shows how B_1 should run for A if he attempts to ram B_2, and, in case B_2 escapes ramming, how B_1 and B_2 must take care not to collide.

Plate XIII, Fig. 3, how B_1 and B_2 should act in case A acts as before. As soon as A's ramming maneuver is detected, B_2 should put his head on A and slow, B_1 should ram A, and B_2 should turn astern of the contestants after the collision had occurred.

Plate XIII, Fig. 4, shows the danger, according to Admiral Randolph, of line abreast and being close together. Either all three will meet at one point, or else B_1 and B_2 will collide.

Plate XIII, Fig. 5, shows how, in case A can outflank the consorts, he may force them into danger of collision.

Captain Fremantle says that the best way for one vessel to fight two, is to try and get them in line ahead, and that the best way for two vessels to engage one is to keep generally abreast and far enough separated to prevent the movements of one from interfering with the other. The two vessels should strive to keep the single vessel between them, and on their bows.

VIII.

To illustrate an engagement of one vessel with two others, we cite the combat between the Peruvian monitor Huascar and the Chilian iron-clads Blanco-Encalada and Almirante Cochrane. The account is taken from Lieut. T. B. M. Mason's work on the operations of the war between Chili and Peru:

The Chilian squadron at Mejillones having coaled, put to sea during the night of the 7th in two divisions; the first, under Commodore Riveros, consisted of the slower vessels, Blanco, Covadonga, and Mathias Cousiño, left at about 10 p. m., and steered down the coast towards Antofagasta; the second, under Commander Latorre, consisted of the Cochrane, O'Higgins,* and Loa, left at about 1 a. m. of the 8th, with orders to cruise 25 miles on and off Point Angamos. This was done in accordance with telegraphic instructions from the director of the war, and differed slightly from the original plan of the commodore, who intended to have moved south along the coast in similar divisions, the first division skirting the coast and looking in at the bays, while the second stood in the same direction but farther off shore, and about 40 miles on the starboard quarter of the first. Either of these plans would probably have entailed the same results. Thus it was that, at 3.30 on the morning of October 8, the weather being fine and clear, the lookout in the Blanco's top reported the smoke of two vessels approaching from under Point Tetas, distant about 6 miles. At daylight the enemies recognized each other. The Huascar ran for an hour to the southwest at full speed, making about 10¾ knots with sixty revolutions and an average pressure of 25.5 pounds of steam, the Blanco and Covadonga following, making about 7½ knots. The Mathias Cousiño was sent in towards Antofagasta, but later turned to the northward and followed her consorts. Commodore Riveros saw immediately that the chase was hopeless; still, on the chance of an accident to the machinery of the Huascar or her consort, or of their turning to the northward and being cut off by the second division, he determined to continue it.

It has been asked, and with good reason, whether the results of the battle might not have been different had the Peruvian ships engaged the Chilians at this time. It is true that the Union was a much more powerful vessel than the Covadonga, and that both she and the Huascar had a great advantage in speed. When, however, we consider that the Admiral's orders were very explicit, and wisely so, that he should run no risks with his ships, as the loss of the Huascar would give the Chilians the command of the sea, it does not seem strange that he should have attempted to escape. Admiral Grau, finding that he was rapidly distancing his pursuers, turned to the northward at about 5.40, and eased his engines by reducing the revolutions to fifty-three. Having been on deck all night, he now lay down for some much needed rest. At about 7.15 smoke was seen, from the Huascar, on the horizon to the northwest, and at 7.30 she having stood slightly to the westward to reconnoiter, the Cochrane†

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* The corvette O'Higgins, wooden hull, built in England in 1867. Length between perpendiculars, 217 feet; beam, 35 feet; mean draft, 15 feet 9 inches; displacement, 1,670 tons; engines, simple, old type; screw, single and lifting; speed, 8 to 10 knots; rig, ship; armament, three 7-ton muzzle-loading Armstrong rifles, on pivot carriages; two 70-pounder muzzle-loading Armstrong rifles, in broadside; four 40-pounder muzzle loading Armstrong rifles, broadside; number of crew, 160 men; condition, hull fair; boilers very old and poor.

† The armored, box-casemated, sea-going rams Almirante Cochrane and Blanco Encalada. Length between perpendiculars was 210 feet; beam, 45 feet 9 inches; draught, forward, 18 feet 8 inches—aft, 19 feet 8 inches; height of battery above water-line, 5 feet 6 inches; displacement, 3,560 tons; engines, two pair, compound, horizontal trunk; horse-power, 2,960; screw-propellers, 2; speed, measured mile, 12.8 knots.

The armament consists of six 9-inch 12-ton muzzle-loading Armstrong rifles, mounted and her consorts were recognized. The Huascar was seen at about the same time from the Cochrane's top, and the Loa was sent to reconnoiter. Admiral Grau, who had now come on deck, probably felt confident that he could elude the Cochrane, as her speed, according to the latest information in his possession, was only 8 knots, and stood for a short time towards the Loa. Finding, however, that the Cochrane was changing her bearings more rapidly than he had anticipated, he stood more to the east, and ordered full speed. The Union, which had remained on the Huascar's port quarter, now, at about 7.45, crossed her stern and passed to starboard of her at full speed. From this moment this vessel, it is alleged, by order of the Admiral, made the best of her way to Arica, followed until dark by the O'Higgins and Loa. The conduct of these three commanding officers has been much commented upon; the first for not engaging, the others for not continuing the pursuit. The three iron-clads were now about 8,000 yards distant from each other. Grau saw that his only chance of escape lay in his speed. At 9.10, as the Cochrane had approached to within less than 4,000 yards, and it was evident that she could cross his bows, he ordered the crew to quarters, and shortly afterward entered his conning-tower alone. In going to quarters an accident occurred in shifting the lead from the ordinary steering-wheel

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on Scott muzzle-pivoting carriages, in a central-box battery, with double re-entering forward and after ports, this arrangement permitting the forward gun on each side a train from right ahead to abeam, the central gun from 70° forward of the beam to 35° abaft the beam, and the after one from abeam to right astern. Each ship carried, besides, one 20-pounder, one 9-pounder, and one 7-pounder. The Blanco Encalada carries two 1-inch ½-pounder Nordenfelt machine guns, one on each end of the bridge, and the Almirante Cochrane one mounted on the knight-heads forward. After the battle of Angamos several Hotchkiss revolving guns were added to the armaments for use against torpedoes.

In addition to these light guns 12 picked riflemen in action are stationed in the fore and main tops, protected from observation by screens. The battery is 7½ feet high, the armor is in two strakes, the lower of which is 8 inches and the upper 6 inches thick on the sides and forward part, while on the after part both have a uniform thickness of 4½ inches. The armor is backed by about 14 inches of teak, inside of which is a thin iron skin. The armored transverse bulkheads forming the forward and after ends of the casemate extend below the water-line. The iron double-bottomed hull is divided by seven water-tight transverse bulkheads, and is protected around the water line by an armor-belt 9 feet wide in three strakes. The middle strake is 9 inches thick amidships, while the other two are 6 inches, all of them tapering to a uniform thickness of 4½ inches at bow and stern. The teak backing behind the armor-belt has an average thickness of 10 inches, and the whole of the armor and backing is fastened to a double thickness of skin plating, supported by massive angle-iron frames on the inside and longitudinal angle-iron guides on the outside. The upper deck, which is flush with the upper edge of the armor-belt, is protected by 3 inches of armor near the casemate and 2 inches at the bow and stern. The casemate overhangs the side about 3 feet.

It is reported that these vessels when in good condition make 10 knots per hour on a coal consumption of from 30 to 35 tons per day. Their coal-bunker capacity is 254 tons. They are bark-rigged and have a complement of 300 men. They can fire their guns by electricity, and their steam launches, of ordinary type, are fitted to carry spar torpedoes. Beside its regular armament each carries a rocket tube and rockets. Neither is fitted for torpedoes.

The stem is a solid casting, ram-shaped, and strengthened by backing and bracing. The ram extends 7 feet 6 inches beyond the bow, and the point is 6 feet 9 inches below the water-line. Condition of the hulls, good; Blanco's bottom very foul; Cochrane's better, as she had been taken to England to be docked and cleaned. The Blanco's bottom is sheathed with wood and zinc.

under the poop to the fighting one in the turret-chamber under the conning-tower. This caused the Huascar to yaw considerably whilst a makeshift tackle was being rigged. At 9.25 the Cochrane, being about 3,000 yards distant, the Huascar opened fire with her turret-guns. The second shot, ricocheting ahead of the Cochrane, entered her unarmored bows, and after smashing the galley and causing some slight damage fell on deck without exploding. At this time the Blanco was about 6 miles astern. The Cochrane did not answer these shots, but stood on until within 2,000 yards, when she opened fire. One of her first shots penetrated the Huascar's armor on the port side and, exploding, entered the turret-chamber, where it set fire to the light wood-work, killed and wounded twelve men, some of whom were at the winches used to revolve the turret, and drove its own fragments and *débris* of all kinds under the turret-trucks, which it jammed for the time being. A 10-inch 300-pounder Palliser chilled shell from the Huascar, fired at a range of 600 yards, struck the Cochrane's starboard side-armor at an angle of 30°. The plate, which was 6 inches thick, was indented or scored out to a depth of 3 inches, the bolts were moved, and the backing was forced in; a beam was also broken. The shell probably broke up.

At 9.40 the Huascar stood a little to port with the intention of ramming the Cochrane, but the latter prevented this by turning an equal amount to port and steering a parallel course. At 9.45 the conning-tower was struck by a shell, which exploded in it, shattering it very much and blowing Admiral Grau to pieces—only one foot and a few fragments being found. Admiral Grau usually directed the movements of his vessel with his head and shoulders out of the top of the tower; the shell, therefore, must have hit him at about the waist. The concussion from this shot caused the death of Lieut. Diego Ferré, the admiral's aide, who was at the fighting-wheel, separated from the conning-tower by a light wooden grating only. This officer's body was mistaken for that of his commander, and caused the erroneous statements which appeared at the time of the combat. No wounds were found on Lieutenant Ferré's body. Part of this shot also disabled the fighting-wheel, and the vessel turned to starboard and ran to the eastward until, the damage having been repaired, she was again headed north. About this time a shell penetrated the armor of the turret (now trained on the port quarter) in its thickest part to the left of the port of the right gun, killing and disabling most of the guns' crews. Among the former were the two gun-captains, and among the latter Commander Meliton Carbajal, chief of staff, who had come to inform the second in command, Commander Elias Aguirre, that he was now in command. This shot furnishes the data for the killing effect of the projectile fired experimentally at the Glatton some years ago, which by a curious coincidence struck exactly the same part of the turret. Relief crews were sent to the guns, but the firing became very wild, as the men were comparatively inexperienced. The right gun had been disabled by the shot above mentioned, which bent the right compressor and cap-square. Lieutenant Rodriguez, while looking out of one of the gun-ports, had his head taken off. An eye-witness reports that the native part of the crew was much demoralized by the loss of their commander. The cabin and wardroom were full of men and officers, some wounded and many refugees from the upper deck, from which every one had been driven by the Nordenfelt and small-arm fire of the enemy.

The Cochrane now attempted to ram, coming at right angles to her adversary firing her starboard bow gun at 200 yards; the center gun missed fire. She missed the Huascar and passed about five yards astern of her. A shot from one of the Cochrane's port guns pierced the armor of her opponent on the starboard quarter, exploding and doing much damage, including carrying away the iron tiller-block, which served as a lead for both ordinary and fighting wheel ropes. The Huascar now again headed to the eastward. A shell pierced the armor abreast the engine-room, covering the engines with *débris*, and killing and wounding several persons in the engine-room gallery. Among the latter were Surgeon Tavara and Mr. Griffiths, the master of the schooner Coquimbo, captured a few days before, and whose crew were forced to render service during the action. The relieving-tackles, which had a very bad lead behind the transoms in the admiral's cabin, were now manned. The steering was very uncertain, as Commander Aguirre had to conn the vessel from one of the lookout hoods of the turret, and the word had to be passed clear aft on the lower deck to the men at the relieving tackles. The Cochrane again attempted to ram the Huascar, firing her starboard bow gun as before at 200 yards, and coming on at right angles with the center guns trained abeam with three degrees depression. She again missed her blow, and passed astern. The center gun was being loaded at this time.

It was now about 10.10, and the Blanco arrived on the scene of action, passing between the Huascar and the Cochrane just as the latter was preparing to ram a third time. The Cochrane, to avoid the imminent danger in which she was placed by her consort's ram, was forced to turn to port and then to the northward, increasing her distance to 1,200 yards. The Huascar turned to starboard and headed for the Blanco with the intention of ramming her, at the same time firing some ineffectual shots in her direction. The Blanco sheered to starboard also, and passing at about 25 yards' distance, poured a broadside into her stern, which killed or wounded all of the men at the relieving-tackles, and also many of the wounded and others assembled in the officers' quarters. The wounded were now removed to the coal-bunkers and store-rooms. The Huascar now stood to the westward.

On account of the number of shots which had traversed the smokestack, driving down soot, *débris*, and smoke into the fire-room, it was impossible to see the gauges. The water fell too low in one of the boilers, which allowed the tubes to be burned through, and caused a great escape of steam. This led the Chilians to believe that they had struck one of the boilers. The small-arm fire at some previous time killed and disabled three out of the four men stationed at the Gatling gun in the Huascar's top, although protected by a boiler-iron screen. The fourth man went below. This must have been done by the small-arm men in the Chilian tops; the latter were higher than that of the Huascar, which had no top covering or hood. The breast-high shield bore no evidence of having been penetrated from below. At 10.25 the Huascar's colors were shot away at the flag-staff, and for some moments she was supposed to have surrendered, and all firing ceased. A loader at one of the guns went aft and hoisted another flag at the gaff. A shot about this time penetrated the turret of the Huascar, killing or mortally wounding every man in it, including Commander Aguirre. Some idea of the terrible effects of this shot may be drawn from the fact that when this officer's body was found and identified, all the upper part of the head was gone, the lower jaw only remaining, four wounds on the right leg, a cut across the stomach, and six body wounds; the right shoulder and arm had disappeared entirely. He was standing at the time to the left and rear of the left gun, with his head in the sighting-hood. Lieutenant Palacios was terribly wounded by this shot. At Commander Latorre's urgent request Palacios was sent on board the next northern-bound mail steamer, but died before reaching Lima.

The command had devolved upon the fourth officer, Lieutenant Pedro Garezon. The vessel was almost unmanageable and on fire in several places; still the engines were kept going, and the left turret gun was fired occasionally. The Cochrane now returned and again tried to ram; she was only prevented from doing so by the chance movements of the Huascar. Both Chilian ships now followed the Huascar, using the bow and center guns, accompanied by an unceasing shower of small-arm and machine-gun projectiles. The Cochrane was struck during the action, probably when she turned off to give place to the Blanco, by a shell which entered her unarmored stern and caused considerable damage, wounding ten men, of whom two afterwards died. The Covadonga now came up and succeeded in putting herself on record by firing one gun. Lieutenant Garezon, after calling a council of surviving officers, sent Sub-Lieutenant Ricardo Herrera to the chief engineer with orders to attempt to sink the vessel by opening her valves. Chief Engineer MacMahon and his assistants succeeded in partially accomplishing this by opening the circulating-valves of the condensers, to do which they had to stop the engines. They were at work on the bonnet of the main injection-valve when Lieutenant Simpson of the Cochrane interfered, revolver in hand. While this was going on below some of the men forward crawled up through the fore-hatch and waved towels and handkerchiefs, seeing which the Chilians ceased firing. The flag was then hauled down. As the Huascar's engines did not stop at first, they were going to reopen fire when she became motionless, probably for the reason already stated. She was immediately boarded by boats from the Cochrane, under Lieutenant Simpson, and from the Blanco, under Lieutenant-Commander Castillo, chief of staff to the commodore; with them came surgeons and engineers.

It has been asked, of what use would the Whitehead system of torpedoes have been in such an action? The answer would seem to be that the Whitehead or any of the diverging systems would have proved to be dangerous and suicidal. The spar type alone might have been used. It is worthy of note that, while the Chilian vessels could always bring some of their guns to bear on the Huascar, the Huascar found herself in many positions where only sheering would bring her guns to bear on them. In fact, this action tends to prove that an all-round fire, even inferior in single guns, will have a great advantage over a preponderance of fire within only given limits.

IX.

TWO VESSELS AGAINST TWO.—In two vessels against two we cannot follow the tactics of two against one. The ships must work together or there is danger of two combining on one. The two vessels should keep within one cable of one another, and, according to Captain Fremantle, in line abreast, and according to Admiral Randolph in his modification of line abreast. Both authorities agree that they must act together and try to isolate one of the enemy and combine on him.

It may be laid down as a maxim that vessels engaging two and two, the advantage is with that side whose ships are close together.

Plate XIII, Fig. 6, exemplifies this, the ships being in Admiral Randolph's formation. A_1 and A_2 are nearest together. B_1 in order to ram A_1 at x must put his helm down the *same instant* that A_1 does, and therefore must have anticipated A_1's move, which is not likely.

Plate XIII, Fig. 7, shows when B_1 and B_2 choose to attack. A_1 and A_2 are in closer formation. A_2 can see B_2's move to ram A_1 well marked before he need put his helm down to ram B_2 at x.

THREE SHIPS AGAINST TWO.—The general rule is for each side to strive and ram the enemy's ships furthest off. The two ships, keeping well together, should try and ram the two ships furthest off of the line. Other than this rule there is no special tactics for the two ships to use. The point to strive for is to use both of your ships on one of the enemy if you can.

For the three ships, a formation is best where two of the ships are in line abreast, or in a modification of it, and the third ship is kept in the rear, ready to assist either of her consorts which may be attacked.

CHAPTER VI.

THE ADMIRAL AND HIS FLEET.

I.

The commander-in-chief of a fleet in time of war has from the outset a very complex duty to perform, viewed from a tactical standpoint. Not only must he be able to exercise his fleet in the various evolutions, and to classify and to arrange his ships in line-of-battle according to their values as regards speed, armament, and turning qualities, but he must know just what types of vessels are suited to compose his squadrons, in order that he may undertake the work cut out for him.

To discuss only that part of the Admiral's duty which relates to fighting his fleet on the open sea or on the enemy's coasts, or to defending his home ports, comes more within the province of these pages.

He must have an intimate acquaintance with the signal-book, and in it should be laid down his plans of battle and the lines of action that will be followed in an engagement. These, in common with all other tactical maneuvers, should be thoroughly discovered to his captains.

The Admiral must be versed in naval strategy, and there are certain rules governing its general principles which he must ever keep in mind. Captain Fremantle formulates them as follows:

> 1st. In any fleet intended for action on the open sea the ships must be so far alike as to be able to act together against the enemy in any tactical evolution which the Admiral may require to be performed.
>
> 2d. If special ships, such as rams, gunboats, or torpedo vessels, are attached to a fleet, they must act independently of other ships, according to a prearranged plan, in which all their peculiar qualities may be best developed.

Since the problem to be solved is how one squadron is to gain an advantage over another of equal force, we think that the solution may be summed up in the following maxims:

1st. Surprise an enemy and attack him when he is unprepared.

2d. Overwhelm a portion of his force with the whole of yours.

There are certain main objects to be clearly borne in mind which follow from these maxims. These are, primarily, so to form the fleet that it may not offer any isolated portion to the enemy's attack, and that the whole fleet may readily be brought into action to repel attack; secondly, so to maneuver as to be able to concentrate your force on a point of the enemy's formation.

To carry out these objects certain tactical action must be resorted to; for instance, disguising to the last moment from the enemy your plan of action, so that it may come to him in an unexpected way or from an unexpected quarter, such as getting him between two fires or massing on one of his flanks. To do this will require thorough drill, the most perfect discipline, and a complete knowledge of naval tactics.

According to Captain Rivet, certain strategical considerations will influence the determination of the commander-in-chief as to whether he should force an action or avoid it if he can. Among them will be found the following:

Are the nearest coast ports friendly, neutral, or inimical?

What are their distances, and how do they bear?

Can re-enforcements be depended upon during the action?

In what direction can it be reasonably hoped that these re-enforcements will appear?

It may be set down as a maxim that a fleet, in *any* formation, if it discovers the enemy near at at hand, as, for instance, through the lighting up of a fog or coming around a point of land, and this enemy in the midst of performing an evolution, it is the duty of the commander-in-chief of the formed fleet to charge the other, even if the formation then in is not a good one for attack, and the formation the maneuvering fleet is striving for is better than his own.

In modern warfare, with great clouds of smoke and rapidly moving vessels, it will be with great difficulty that friend can be distinguished in action from foe. To prevent accident, it is possible that nations will assume some color or some distinguishing mark for their fleets, as they have color and cut for their army and navy uniforms. We can conceive of a weak fleet, as a piece of strategy, assuming the enemy's livery, and adopting some other means of distinction, for the time being, which will permit them to be recognized by their friends.

Lieutenant Campbell says:

> I look upon the system of communication between the Admiral and his fleet as vitally important to the success of an action in the present time and in the future, even more than in days gone by.

Referring to his own Navy, Mr. Campbell says:

> With soft coal, as now carried, it is literally impossible to make out the Admiral's signals, and this is still more palpable when topgallant masts are down and the ship is clear for action.

Coal, therefore, for purposes of fighting at sea, must be smokeless. Since we, in our Navy, burn generally anthracite coal, we are to a great degree spared the annoyance of smoke, but whether we can develop the same high engine-power with this fuel which can be done with the softer coals we leave to others to decide. In a pitched battle, though, the enemy's smoke puts us all in the same category.

As this will be the case, battle signals must be very simple. There should never be a hoist of more than three flags, and shapes should be substituted for colors, if possible, such as is used in *Distant Signaling*, according to the International Code. Still better, signals made up of cones, double cones, cylinders, and balls should be employed.

Most authorities agree that in action, on account of smoke, the weather-gauge is almost as necessary now as it was considered to be in the days of Rodney and Nelson. There are tacticians, however, who believe that this position does not possess the merit claimed for it, and prefer to have the wind set in a direction that will bring it abeam for each vessel when attacking. Lieutenant-Commander Goodrich, U. S. N., says that the weather-gauge prevents you from seeing where your missiles strike, a very necessary point to be sure of. Under all circumstances, we believe that the Admiral should so maneuver his command as to be on the weather end of his line.

Ships, in all probability, will have to coal on the open sea, as, for instance, when maintaining a blockade or in long voyages, especially if sail power is still further reduced. Probably no nation has had greater experience in this respect than our own, and in the event of war now, unquestionably our experience will be still further enlarged, as we have no colonies upon which we can rely, and coal undoubtedly will be considered contraband of war. Several methods for coaling on the open sea have been proposed, and one suggested by Lieut. R. S. Lowry, of the British Navy, seems to possess, at least, the claim of novelty. His plan is substantially as follows:

In coaling at sea the coals should be taken on board with the vessel steaming ahead, especially if there is any sea on, as will likely be the case nine days out of ten. A steamer should be fitted to carry a cargo of coal already put up in "carriers," which resemble somewhat the life-cars now used on sea-coasts to save life. Each carrier holds one ton or less. The collier is towed on the quarter of the ship, and, besides the towing hawser, there is a jack-stay from the quarter of the collier to the bow of the ship. The carrier is hauled along this last line in the water, and taken on board the ship by a yard-and-stay, if coaling over all, or by yard-arm purchase and gurnet if coaled through a port. The empty carriers are sent back the way they came.

The strategic value of coaling points is apparent. Nations with navies must make sure in time of peace that their vessels will not be rendered useless in time of war through a lack of fuel-supply. This supply may be divided into two classes, *fixed*, or coal stations, and *movable*, or by steamers using a temporary base. Probably the carrying on of a war will exact both systems being in a degree maintained. Each has its advantages, but undoubtedly the last category presents the greatest number.

We have said that a necessity for coal supply must be met in a time of peace; that is, either the coaling station must be protected by diplomatic methods, or else by regular fortifications and marine defenses. In most cases this last condition would necessitate purchase of the territory, and the coal station immediately partakes, more or less, of the nature of a colony. In time of war this station will have to be guarded by vessels, which could be otherwise employed, and therefore develops at once a disadvantageous aspect. Again, it may be a long distance from the theater of war, in which case no small percentage of fuel will be burned by a vessel going to this station and returning to her duties with the fleet. Another point: the enemy will do his best to capture it, and since ships will probably have to keep up the supply at this depot, he will try to seize the colliers *en route*. One of the few advantages of this means of coal supply is that at the outbreak of hostilities coal can be obtained whereas otherwise the necessity would have to be foreseen, and vessels with fuel-cargoes be dispatched in time to supply the fleet.

To insure a coal supply under the second category, in time of peace, the Government must encourage a large proportion of the fast merchant steamers to be so built that they can carry cargoes of this commodity to such rendezvous as the nature of the war shall decide. These rendezvous, from a strategic point of view, should be as varied as possible in location, so as to mislead the enemy. The advantages of a movable coal supply here become apparent. The location of the depots not being known to the enemy, the capture of the supply vessels is much less likely. Then, the points of supply being near the base of operations, little or no coal will be consumed uselessly. The drawbacks to this method of supply are that a rendezvous where the fleet could coal, having a hostile environment, would be harder to establish, and, if established, would be more likely to be attacked in force. Then, again, steamers at the outbreak of a war may be hard to obtain, the distances that they have to be sent may be very great, and the fleet might suffer in consequence.

II.

Admiral Aube remarks, "A fleet superior in numbers will be, from the commencement of a naval war, the mistress of the seas, other things being equal."

According to Captain Noel, there are two fundamental principles to be observed in preparing a fleet to operate in time of war:

> 1st. In selecting weapons for service with a fleet, choose those that are capable of inflicting the greatest possible injury on the enemy with the least possible danger to yourself.
>
> 2d. In the organization, maneuvering, and formations of a fleet, and in the use of signals, study the utmost simplicity, arranging everything with a view to efficiency combined with the fewest prospects of damaging friendly ships.

Ships may be classified under the following heads, and may be combined to compose a fleet of armor-clad line-of-battle ships: A reserve of armor-clads, observation squadrons, cruisers (preferably of steel), commerce destroyers, and dispatch vessels. Ships from these classes, either combined or single, will operate especially on the high seas. Coastwise squadrons will be composed of armor-clads, gun-vessels, tenders, harbor flotillas of gunboats, torpedo-vessels, torpedo-boats, and their tenders. There are other vessels that must be used *with* the fleet which may not be considered *of* the fleet, and which are only furnished when required to fulfill some special duty.

Captain Noel, for warlike purposes, would have his navy divided as follows:

1st. A fleet of heavy ships of the line. These vessels, by reducing their top-hamper, and having only topsails, courses, and fore-and-aft sails bent, would save enough weight to permit stowage of extra coal. They should be provided with heavy towing hawsers.

2d. A squadron of cruisers attached to this fleet, all of great speed and fully rigged. Their duty is to reconnoiter, make prizes of hostile cruisers, and to obtain information from shipping.

3d. Dispatch vessels.

4th. Torpedo-boats of a size large enough to keep the sea on their own account. In cruising they should keep with the ships whose tenders they are.

Captain Harris says:

> As the speed of the slowest ship is the speed of the fleet, no vessel should be assigned to the line of battle of less speed than 12 knots. With the swiftest fleet lies the option of giving or declining battle, and also whether or not the battle will be limited to artillery alone.

Lieutenant Besson, M. F., asks the following question concerning a reserve squadron: Should the fleet be divided and fight with a certain number of ships, letting the others keep out of the battle until the formations are broken up, or ought the fleet to be kept together and should there be no reserve? This query he answers by saying that every fighting formation presents two feeble points. These are the ships furthest off; that is, the outside or flank vessels. Divide your fleet into detached squadrons and you increase these feeble positions, and therefore diminish its power. If your fleet is much larger than that of the enemy it might be done; otherwise not. Is it not more rational to put the reserve on the field of battle to strengthen some part of your line?

There are three places to put the reserve; they can either be put between the line-of-battle ships, in line abreast, so as to diminish the distances without adding to the length of the line, or they can be put behind the center or wings of this same line abreast.

In the first case they interfere with the free movements of the ships, which is a bad feature, but there seems to be no fault to find with the other two positions in which we consider they can be placed.

The latest authorities combine in the opinion that there should be no regular reserve squadron, believing that all vessels of any size and strength should be in the line-of-battle.

We would call attention to the necessity of having an efficient squadron of "lookout" vessels. Two squadrons bearing down on one another, and steaming at the rate of 10 knots, pass over three cables' length in one minute. Hence the necessity of great speed in these vidette vessels.

These vessels will probably be unarmored cruisers, but there are many tacticians who are of the opinion that, besides their lookout work, they should be placed in the line of battle. Admiral Penhoat says, decidedly:

> Large cruisers of great speed and few guns, or of feeble battery power, should be fitted with torpedoes and be put in the line of battle. Such vessels will increase their value if to these qualifications is added turning power.

A fleet should have its videttes stretched over a distance of 20 miles ahead and 10 miles on each flank.

It must be remembered that this vidette or lookout squadron is a regularly organized body, and differs entirely from single vessels sent out from any squadron of the fleet to observe the enemy or to draw his fire. These last may be termed skirmishers.

In that part of the fleet termed "the convoy" must be vessels fitted to carry ammunition. As they will have to supply the fleet under all conditions of environment, their fittings as regards protection from projectiles of the enemy, defense from any attack, and ability to supply their cargo becomes a serious war problem. They should be supported by rams and torpedo-vessels (these last they should carry), and by one or two powerful corvettes. These corvettes should be furnished with good towing hawsers. The armament of the ammunition ship should be a large number of machine guns. The enemy will do their utmost to destroy or capture such a vessel.

Large, clumsy ships, with inferior speed and large evolutionary circles, should never be permitted to cruise alone, no matter if they have heavy batteries and are well protected by armor.

III.

The Admiral should supply to each captain commanding a vessel under him, copies of the "helm table" and speed table" of each vessel of his fleet, so that it can readily be found, on the commander-in-chief signaling the number of revolutions of the screw of his flagship, how many revolutions are necessary for each ship to make in order to preserve the formation. Then, again, each captain, knowing which ship has the largest turning circle can, when this vessel signals her evolutionary helm angle, judge what amount of helm to give his ship. Mast-head angle tables, for open and closed order, must be prepared for each ship both when in cruising and in fighting trim. Each captain must have these *data.*

All professional writers call attention to the necessity of the captain being thoroughly informed as to the Admiral's plans, and agree that they should be strictly conformed with, especially in respect to the speed of the ship and the intervals and distances to be maintained. If the commanding officers of ships are not thoroughly imbued with the spirit of the commander-in-chief, and are not conversant with his tactical plan of action, there can not only be no success, but only disaster and defeat can be looked for.

IV.

A great diversity of opinion exists as to the post the Admiral should occupy in an engagement. No doubt he should be in a position where he can see and where he can be seen of all, so that the simple signals with which he must content himself can be easily observed. Personal example, however, will weigh more in the scale of victory than signals, and therefore we find that since all actions now are based on the ram, the Admiral's post is in the place of danger; he must lead into battle. Admiral Penhoat says: "He should lead in in line ahead. He can then change direction of the fleet without using signals."

By some authorities the Admiral is placed in the center of the line; this is an excellent post should he elect to fight in two lines ahead or even in line abreast. The only point to be made against this position in this latter formation, is that the commander-in-chief's movements and signals will be more obscured with smoke than if he was in some vessel large enough to lead into action, but which, not having been given a number in the line, can shift to the weather flank. As the flanks will be the points most likely to be attacked, we conceive it to be the place of the Admiral to make his presence felt on either one or the other of them.

There are writers who believe that the post of the Admiral should be with the reserve, either in a special ship or in one of the armor-clads We hardly see the philosophy of this in a pitched battle, as the flagship would probably be inferior to the armor-clads of the line-of-battle in one or more respects.

A German writer has the following remark on the post of the commander-in-chief during an engagement:

> The Admiral's flag belongs on the largest and most powerful vessel, which should outshine all others as a brilliant example in the heat of battle. History shows that the Admiral must himself be in the midst of the fight. If he wishes to be the vital element in his ship, and to make the best use of all the components of his command, then he must put himself in a position to see everything and to be seen of all.

CHAPTER VII.

FORMATIONS.

I.

There are tactical precepts which are common to armies fighting on shore and to fleets engaging at sea. Napoleon says: "Concentrate your forces; do not have a weak point. To move *en masse* and with rapidity on the enemy, and to attack him where he is weakest, is the secret of victory."

The principle which answers to this is *concentration*. This precept of war, which is universally admitted to be excellent, is especially applicable to fighting with rams. To weaken or to destroy by greater numbers a part of the enemy's fleet, then to be able to bear down afresh on some other part of his formation with a superior force, is the special object of all attacking maneuvers.

A fleet is in order of battle when all the vessels composing it can use perfectly all the means of offense and defense that they are provided with, without interfering with one another or detracting from their mutual support. The offensive weapons of the line of battle are guns, rams, and torpedoes.

The principal conditions which a formation of a fleet for attack should fulfill are:

1st. The largest amount of liberty of evolution for each vessel, and at the same time the best employment of the peculiar fittings of each ship for attack.

2d. It should permit the execution of every maneuver in the least time, with the greatest speed.

3d. It should be simple, flexible, and easy to keep, under all conditions of sea and weather, without exposing the ships to collision.

4th. Unity of direction of each vessel's course must be preserved. The vessels must maintain their stations, and they must be able to change rapidly to the direction of the enemy's attack.

5th. It should be such as to permit the fleet to be able to cope with any particular necessity for preservation imposed on them by the enemy.

6th. Between vessels of the fleet there must be mutual support either for attack or defense.

7th. It should permit the fleet to be kept well together under the eye of the Admiral, so that each vessel can see his signals.

In dividing the fleet, should the basis of division be either the group or section, attention should be paid to the equality of the ships which are to act together, more especially to their maneuvering capabilities. These vessels should exercise together, should learn to move as one, and should only be changed under circumstances of necessity.

In old days the signal-book was shut when the fleet bore down upon the enemy. Now it may be required to maneuver as a fleet until actually engaged. For this reason Captain Fremantle thinks that a long line of ships, either ahead or abreast, will be impracticable.

Any attacking formation will finally disappear during an engagement, and the fight will, in all probability, settle down to actions between vessels. The Admiral must be careful to designate certain vessels to act as rallying points, or as *nuclei* for the re formation of his fleet, either for purposes of concentrating for renewed attack, or to combine for mutual support to fight in retreat.

II.

A fleet or squadron can be formed as follows:

1. In line ahead.
2. In line abreast.
3. In bow and quarter lines.
4. In triangles or quadrilaterals of different shapes.

The first three formations which are simple, can be made *compound* or *complex* by doubling or repeating the formation in some peculiar manner, as, for instance, forming in two lines ahead, alternate line abreast, in naval square, in double echelon, &c. The fourth formation is always *compound*

The basis of fleet division is either the ship, section, or group. The most modern idea is probably that each line-of-battle ship is a unit in itself, and in order that it may be thoroughly effective it must not be hampered in the use of any of its weapons by having to act as part of a formation with any other vessel or vessels. Mr Besson says, although the tactical unit *is* the single ship, and while her first duty is to act for herself, still a designated vessel next to her in line should be combined with her to develop the best results to be obtained with the ram for each vessel.

Captain Courbet, M. F., in 1872, in order to apply in the best manner the principle of concentration of a larger portion of his force on a smaller portion of the enemy, took as the tactical unit *two* vessels, which he called a *section*. One of the vessels was termed the leader, and had the other vessel under his control. These two vessels, in English, may be designated as the "leader" and his "mate." They must combine their energies in attack and give mutual support.

Admiral Penhoat also favors the interdependence of two ships, and in all the formations and movements discussed by him and by the writers who assume this tactical unit the two vessels act together. As a general thing it was contemplated that the best position for the subordinate vessel was on the quarter of the leader, so that all lines ahead were alternate lines ahead, and all lines abreast were alternate lines abreast. We have said that Mr. Besson believes in the necessity of two vessels acting together, but he differs from all other tacticians as regards the relative position of the two in attack. Believing that the plan of attack should be based upon the use of the ram, he shows that the ships should be *abreast of one another* in order to develop this weapon to its fullest extent, and that therefore the line of battle should be a line abreast. He also goes on to show that any other relative bearing between the two vessels puts one or the other of them at some disadvantage as regards helping its consort.

Admiral Penhoat, in common with most writers now, believes that the fleet should be made up as follows: Two vessels should compose a section; two sections a division; two divisions should form a squadron, and two squadrons a fleet. This would make the fleet composed of sixteen vessels. If there is a less number than sixteen, the squadron must still be composed of eight, and the rest must be over, and be exercised as another division or squadron.

We now come to the consideration of the *group* as a tactical unit. During many years the students of this science were struck with the necessity of so dividing the fleet that the particular qualities of each ship could be given its proper value, and the divisions of the fleet into groups found numerous defenders. Until lately this has been a favorite system, since it was considered to develop in the greatest degree the following points:

1. Each ship's battery was clear.
2. Each ship was considered to be entirely unhampered in its movements as regards ramming.
3. There was the greatest mutual support between ships.

Although the pèloton or group was originally intended as a formation to cruise in solely, and ships moving in this order were without any arrangement, save that one was designated as the leader, still it soon came into prominence as a fighting formation, and was especially favored by the English. In 1868 Captain Semetchkin, of the Russian Navy; was entirely impressed with its usefulness, and in his work on "Naval Tactics" divided the squadron into two divisions, and each division into two groups, composed of three ships each. These groups were either equilateral-triangular or rectangular-triangular, with equal sides, the hypothenuse forming the rear face of the group.

Captain Lewal, of the French Navy, divided the squadron into three groups, each group containing three ships, one being designated as "group leader." Mr. Laughton's plan is nearly identical with this. He makes the basis of fleet division a *squadron* of three vessels, each squadron to have its admiral. He gives as a reason, that each vessel is alongside of his admiral, and therefore in the handiest position to send or receive signals. Besides this the admiral is immediately supported by the ships of his command.

Lieutenant de Penfentenyo, of the French Navy, in his work on "Rams in Battle," says that the tactical unit is a group of three or four armorclads arranged in a triangle or square. He further says that a squadron should contain at least two divisions, and a fleet two squadrons and at least twelve armored ships.

Lieutenant Campbell, speaking upon this point, says that the "evolutionary unit" seems to rest between a group composed of two, three, or four ships. With two ships, one ship should be four points on the quarter of the other, and two cables from it; with three ships, the third ship should be three cables from the second ship and four points on *her* quarter. (See Plate XIII, Fig. 8.) With four ships, the fourth is placed as in the figure.

According to Captain Fremantle, the subordinate vessels of a group should be the handiest and fastest.

Mr. Campbell says, that in a fleet actually organized for war, a group should consist (if the fleet be sufficiently large) of three line-of-battle ships, three tenders, and six torpedo quarter-boats.

Commander Noel also divides the squadron into groups. He adopts the triangular group, which he forms in different ways. (See Plate XIV, Figs. 1, 2, 3 & 4.) He says: "Since, nowadays, fleets are and must be made up of vessels of different powers, and whose parts to play in a fight are essentially different, the group-leader can, being the staunchest, call his consorts under cover." Furthermore, he takes issue with Captain Colomb on the point of the latter's condemnation of the group system for either attack or defense, and gives cases to show that groups can maneuver to pass down the line of an enemy with a narrow front if required, and that they are most mobile for change of formation to ram, and, that in case of collision with the enemy, they will not pile upon one another as they would do if they were in line ahead; also, that if the line *was* broken, re-formation is more feasible with this system.

We may observe right here what may be set down as a maxim: The victory will probably lie with that fleet whose formation will permit it to keep its integrity the longest.

In regard to the number of vessels comprising a group, Captain Fremantle says, "There is no special virtue in the number *three*, and there is no extraordinary strength of formation in the scalene triangle." This most favored grouping in the English service consisted, perhaps consists, of one vessel leading, termed as, by Captain Lewal, the group-leader; a second vessel two points abaft the beam of the first and one cable off, and a third vessel on the other quarter of the first and two cables off. We believe that the English signal-book now permits of great latitude in the use of this system.

Lieutenant Campbell is one of the greatest champions for the group formation, and does not hesitate to say, "I believe that no formation is better adapted to the development of the torpedo, the ram, and the heavy artillery of the present and the future."

Lieutenant Cattori, of the Italian Navy, believes in equilateral-triangular groups, with the groups revolved through 30° about the center of figure. Several of these groups in line abreast have the advantage of the group system and that of line abreast in three lines. (See Plate XIV, Fig. 5.)

We can hardly look upon this formation as anything but *pretty* theoretically, as the formation being so hard to keep would be certain to degenerate either into isolated groups or into a formation in three lines. It is unquestionably clumsy to maneuver in.

Lieutenant Besson says that the result of the drill in the French squadron of evolutions was such as to condemn the group system *in toto*. In speaking of a formation for attack, he remarks that all orders on *lines* of bearing, and particularly the group formation, must be abandoned. "The group formation is the worst of all" are his words. He goes on to say that in the group formation the vessels do not give each other such efficient support as to make up for the clumsiness of their arrangement. Line ahead in groups is a bad cruising order, as the slightest movement of the helm or change of speed may cause a collision. In every case it is difficult to imagine a fleet going into action formed in this way.

At first glance it is very different with line abreast in groups. We see here, in each group vessels can easily change speed; the wing vessels especially can do so without danger of collision. Although the formation may be said to possess all the merits of supplementary lines, still the difficulty is that changes of direction, maintaining the group formation, are well-nigh impossible. This, and from the fact that this arrangement exacts an unanimity of action between ships which is hardly to be brought about, would seem to call for an absolute rejection of the system.

Lieutenant Rivet, M. F., calls attention to the following defects in this system. He says:

> At first glance, the three triangles that can be formed from a group of three vessels seem to fulfill all the requirements of a perfect formation, but when we come to analyze it, we find the length of time that it will take these ships to change the form of their triangles or direction is too long to recommend the group system as a fighting formation.

The most competent authorities are unanimous in condemning it. Each group presents two weak points, one on each flank, where two of the enemy can easily concentrate, as shown in Plate XIV, Fig. 6.

In regard to the fundamental organization and numbering of the fleet in line-of-battle, we lean towards the method given by Admiral Penhoat. The fleet should be considered to be in line abreast, arranged as in Plate XV. The first guide on the right of the line, the second on the left. These act as general guides. There is also a right and left guide to each squadron. These guides will be most particular in regard to speed, course, and mutual bearing. It will be seen that the guides keep half a ship's length ahead of the line; Admiral Penhoat and Admiral Randolph both say that this is as easily done as to keep exactly abreast. When the fleet is in line, the Admiral should signal the direction of the dress.

We favor this method of assigning numbers to the fleet, since it will cover any system of tactical division. (See Plate XV.)

The numbers for the line-of-battle are sixteen, or as many more as needed, up to thirty-six. If the group or division system was used with four to the group, the numbers would run as in the figure. If there were three vessels to the group the numbers would be in the following order: 1, 12, 13, 2, 22, 23, etc. If the section system or combination of two vessels is used, the numbers would run: 1, 12, 2, 22, 3, 32, etc. If the tactical unit was the single vessel, we would still have to use the method of numbering used in the section system, so as to have numbers enough for 16 vessels. It will be seen that the *leader* has always a single number, and that the subordinate vessels have a two-figure number; the *tens* figure telling the number of its section or group, and its *units* figure the number in the section or group. The line-of-battle should first be furnished with numbers, then the reserve, then the look-out squadron, and finally the convoy.

The probabilities are that this system does not furnish numbers enough for all the squadrons of a large fleet unless the group system of assigning numbers is used. The only point to be looked out for is, to have each distinctive squadron numbered on some system. These numbers need not necessarily run from right to left; in fact, the left group or section, most likely, will have the *leader* on the flank, and it is this vessel which should receive the single number.

Formations may be either natural or inverted. They are *natural* when the numbers run in order from an assumed right towards the left (the fleet or squadron being in line abreast), and *inverted* when the squadron has changed course simultaneously sixteen points. The natural order should always be maintained except when forced by circumstances to form in an inverted formation, which should be only as temporary as possible.

It will be understood that each ship has an *invariable* or *distinguishing number*, as explained above, and a *number in line*, which is her number from the ship on the right, the squadrons being in natural order. The ship on the right should be No. 1.

The Admiral should assign himself a number in the line, leaving a tender or some small vessel to take his place, should he see fit not to occupy his billet.

In regard to open and close order, Captain Fremantle says:

> We may remark on the much greater difficulty of keeping anything like a good station when in "open" than in "close order"; and now that "close order" is specially ordered in a fog, it is abundantly clear that it might and should be maintained under all circumstances by night and by day, except in very bad weather.

Mr. Laughton defines "close order" as 150 yards and "very close order" as 100 yards. The general rule, however, in tactics is, that no interval or distance should be made small enough to admit of two vessels fouling in any manner. Admiral Penhoat is of the opinion that the distances and intervals should not be arbitrary, but be laid down with great rigor, and Captain Rivet says that the distances between ships should be two cables, or two-thirds of the diameter of the evolutionary circle.

The distances between vessels in double line abreast should be a little more than in simple line abreast, but should not exceed four cables, or once and one-third the diameter of the evolutionary circle.

The intervals between two lines should be about six cables for a speed of ten knots. Supposing each fleet charges at ten knot's speed, the two will come together at a rate of twenty knots. This rate makes the second line engage the enemy two minutes after the first. This interval ought not to be made smaller.

III.

It is hardly necessary, we take it, to go over the thousand and one modifications of the three or at most four simple formations in which a fleet can be arranged. Nearly every tactician has his favorite methods, differing somewhat from those of other tacticians, to which formations he gives special names, and special rules are laid down to preserve their integrity.

It will perhaps be well, however, to look back twenty years, when broadside fire was the basis of attack, and ships had only moderate speed, and see the multiplicity of formations that were considered to be necessary, then glance at the situation to-day, and observe what simplicity of order is forced upon us by the ram, and by the enormous engine power of ships.

In 1866 there were fifteen simple and compound formations. These were drilled in, and undoubtedly were found to be not only satisfactory but imperatively necessary. To-day, according to Lieutenant Besson, only two simple formations are retained, line ahead and line abreast; and two compound formations, two lines ahead and two lines abreast.

Formations are either simple or compound. Simple formations are line ahead, line abreast, and line of bearing. This last is sometimes termed *échelon*, and when ships are in this formation they bear from one another all the way from two points forward and abaft the beam, relatively, to four points.

Compound formations (see Plates II & III) are those where the simple formation is repeated, as two or more lines ahead, two or more lines abreast. On two lines of bearing making different angles with each other, and known as *chase* and *retreat* formations; squares, which are either lines ahead, lines abreast, or lines of bearing of unequal length, but where the distances and intervals are equal in size and number;

modifications of the square, and the numerous group forms. By some writers, compound formations are confined to designate the group; by others, the group formation is called "special." All this is a mere question in terminology, and we prefer to class as compound all those formations which are not single lines ahead, single lines abreast, and single lines of bearing.

According to some authors, line ahead is too extended for an attacking formation, but it is very useful in going through a narrow channel. The line abreast and the line of bearing take up too much sea in width, and they necessitate changes of direction that are very difficult to make when the enemy is sighted.

These writers either depend on compound formations for combat, or else believe in no regular attacking formation at all.

According to Lieutenant Cattori, of the Italian Navy, the line ahead is only useful in tortuous channels, but in other cruising it is of little or no account. As a fighting formation at sea he says it has no place. Compound lines ahead may answer in cruising in special cases, and it is useful in time of war to force a passage and to enter a harbor under fire. In effect, it is sufficiently concentrated, yet simple to permit change of direction without change of formation. The nature of the defense from the shore would have to determine whether the ships would have to be lashed together or whether the compound lines ahead would be two lines ahead or alternate line ahead. The commander-in-chief, in this case, most authorities agree, should not be in the line. A French tactician says:

> Line ahead is probably the best formation for entering a harbor, even where mines are suspected. If the torpedoes are in a line perpendicular to the line ahead, only one ship would be blown up. If they were more scattered, going in this formation will increase the chances of some of the vessels getting through. Of course a suspected locality should be thoroughly countermined.

Leading into a fight or bearing down on an enemy's position in line ahead has its advantage; it does away in a great measure with the necessity of signaling. Then, it is easier for the captains of the vessels, as they have no dress to keep, but only to maintain their position in the wake of the next ahead. According to Admiral Penhoat, with a small fleet, say of six or eight vessels, the best arrangement is in line ahead in single column, with a distance of two cables between ships. If a vessel must slow for some cause, she should steer out of line. The line-of-battle is most easily formed from this formation by changing direction eight points and then coming into line abreast. (See Plate XVI, Fig. 1.) If the fleet is large, the Admiral recommends bearing down in two parallel lines, which is double line ahead, for the reason that if all the vessels were in one line they could not see the Admiral's signals, and also they would take too long to get into line abreast, which seems to be the favorite formation for attack. Double line ahead can be formed in two ways: the even number may form the second line by falling out to starboard or to port when formed in one single line ahead, or it can be formed from the last half of the fleet. (See Plate XVI, Figs. 2 & 3.)

When the lines are formed in the first manner, and the odd number are in the right-hand line, and the two lines have an interval of about five cables, the formation is an order of battle in two lines abreast, moving by the flank. It is easy to see that a fleet established in this formation can come quickly into the order of battle in two lines perpendicular to the bearing of the enemy.

Admiral Penhoat's advice, then, is that, as a general rule, it is better to have one line even if it is a little long than to have two or more, especially when in the same waters with an enemy. The limit of one line is eight vessels. If there are more than eight, two lines ahead *must* be formed. Change of direction is made without difficulty. In each line ships can drop off on the off side without interfering with each other. The smallest interval between the lines should be greater than the diameter of the evolutionary circle, so that in case a vessel had to drop out on the side nearest the other line, she could turn without danger of collision. This interval should be from four to six cables. The maximum interval between the lines need only be sufficient to let the fleet form line abreast on a line of bearing eight points from the old course.

It is difficult to bear down on the enemy in any spread-out formation, and preserve the stations of the vessels. If in bearing down, the enemy shifted his bearing to the right or left, he can often be kept in front by changing the course without changing the formation or the absolute bearing of the lines. In steaming in line abreast, the captains of each ship must preserve for their vessels—

1. The course.
2. The bearing.
3. Their station in the line.

Each ship's compass should be perfectly adjusted, or its errors must be exactly known. This is most important. Chiefs of divisions are guides for their divisions, and they should keep themselves just a little ahead of the alignment when the fleet is in line abreast.

From Lieutenant Farret we learn that simple line abreast only answers as a cruising formation for a limited number of ships; as an attacking formation in the opinion of some it is too extended even with a fleet of ten ships, and the flanks are without protection. This bad quality does not apply, however, to line abreast in two or more lines, and although this is not properly a good cruising order, it is, according to Lieutenant Cattori, an excellent formation when advancing upon or when feeling an enemy. It also answers in many cases as a fighting formation.

Captain Rivet has the following to say about simple line abreast:

> As a cruising formation it is not good; especially is it bad at night. As a formation for attack with rams it is good; for artillery fire it is bad. Any compound line abreast is better than the simple formation. Alternate line abreast, with the distance and intervals as small as possible, is the best arrangement of this formation.

Admiral Randolph has the following remarks to make on the bow and quater-line, or a formation in the ordinary *échelon.* "It is," he says, "hard to preserve; the opportunities, however, for using the battery are very good. It is not the most efficient for mutual protection from ramming, as the sternmost of two ships receives none from her bow neighbor, and the leader of two not the utmost possible from her quarter neighbor. Furthermore, it is not a good formation for ordinary steaming as it is hard to maintain your station, and is difficult to change direction in, although it permits great liberty of movement of the vessels themselves."

We now present the views of Mr. Laughton in regard to fleet formation for attack. He is of the opinion that the fleet could best be formed on a modification of the "naval square" (*carré naval*) of Admiral Count Bouet-Willaumez. The French formation is limited to nine vessels. If this number is maintained, it will be seen that the formation is not only strong, but presents the same shape, no matter how the vessels head. Of his special formation (see Plate XVI, Fig. 4) he says he believes that there would be all the necessary advantages of the square in the formation he suggests, and that every movement could be performed under one general signal, "change front (so many) points to starboard (or port)."

Groups are not necessarily triangular. Some writers believe that each group should be exercised as a squadron, but that the leaders should always be in one of the simple formations; the distance to be sufficiently great between the leaders as to prevent any interfering between the groups. Although this system certainly aims at keeping up a squadron integrity for a longer time than any other, still the maneuvering of even two groups together will be found to be very awkward, take up too much time, and the vessels, during the evolutions, could not give one another sufficient support if attacked at this time.

In Plate XVII, Fig. 1, we give several forms in which groups can be, and the tactician, who recommends them, explains their uses as follows:

1. The equilateral triangle, for ramming or as a cruising formation.
2. The group on a line of bearing. For flanking an enemy; for defense against an attack by ramming, and sometimes as a formation for attack.
3. The group for evolution or for using the battery.
4. Group in line ahead.
5. Group in line abreast.

In regard to special formations, Admiral Randolph favors a line of bearing in which the ships are in *échelon* of not more than a point forward and abaft the beam. (See Plate XVII, Fig. 2.) Such a formation, he says, is as easy to maintain as line abreast. In this formation Admiral Randolph claims:

1. The fire is left clear.
2. The closest order is maintained.
3. It gives the maximum of mutual protection.
4. It is a rapidly formed formation and can be deferred to the last moment, and thus mask the intention from the enemy.

The distance between the ships is set down as one and one half to one and three-quarter cables.

Some tacticians divide formations for cruising into those to be followed in time of peace and to those applicable to a period of hostilities. Captain Attylmayr, of the Austrian Navy, believes that in time of war the best cruising formation is in line ahead in groups, and in time of peace line ahead, either single or double, chase formation, or the square. Mr. Besson, however, is of the opinion that for all purposes of cruising, line ahead in divisions is the very best for squadrons; that is, the squadron is in two lines ahead. From it the line-of-battle can be most easily formed. The Admiral can see all his ships and be seen of all; the squadron is compact, and the tenders on the wings can easily keep it advised of the approach of the enemy. When cruising the place of the Admiral is leading one of the lines.

Cruising in route formation consists in dividing the fleet into sections of two vessels, or groups of three vessels, and each section or group governing itself as a little squadron, all steering the same course, set by the commander-in-chief, and each section or group maintaining proper signal distance with him. This system is excellent for a long run, as, for instance, crossing the Atlantic. The Admiral should furnish his captains with a list of several rendezvous, and assign certain dates when these rendezvous would expire.

Lieutenant Farret says that the groups first used in the French Navy were in the form of an equilateral triangle. This formation was:

> Not for fighting purposes, but as an habitual order of navigation, so as to take the place of lines of ships in each other's wake; an order compromising for steamships, especially at night.

The equilateral-triangular group became usual later as a "*peloton de combat.*" For a strange fact, Commander Noel puts *his* groups in such a position during the night that the squadron is virtually in line ahead.

It would seem that a good night formation would be line ahead in two columns or lines. Each column should not contain more than six vessels, better still if there were only four. In time of peace, or away from the enemy, the leader of each line should use the forward electric light to illuminate the fore part of the leader of the other line, and the after electric light to illuminate the fore part of the rear ship in the other line. (See Plate XVII, Fig. 3.) If the officer of the deck of either of the leaders, or of the rear ships, draws into the glare of the lights of the leader of the other line, he will know that he is drawing ahead of his station.

When convoying, the convoy squadron should be so distributed that the heavier ships during the day should cruise in chase formation with the lighter vessels, acting as "whippers-in," keeping the convoy well within the angle. There should be tenders to act as skirmishers ahead, on the flanks, and a swift one to cruise astern. During the night the convoy squadron should separate and cruise on the flanks. If the convoy is large it should be divided.

Although massed or in square is not in good formation for fighting it is a most excellent one for reconnaissance; probably the very best for a small number of ships.

Fighting formations all come within one of the four following categories:

1. Narrow front—great depth.
2. Extended front—slight depth.
3. Front and depth equal.
4. Groups.

The first category is represented by line ahead; the second, by lines abreast, chase and retreat formations; the third, by the square, and the fourth, by every formation that may be included in the group system.

A good order of combat demands the arrival of all the vessels as near together as possible on that point of the enemy's formation where the attack is made. It also must possess the following qualities:

1. It must be easy to keep.
2. It must be easy to re-form in.
3. It must lend itself, by its flexibility, to all the combinations required by the Admiral.
4. The vessels composing it must be so disposed as to give one another the maximum of mutual support.
5. The vessels must be able to use all their warlike outfit, which includes helm and speed power; the use of their rams, guns, and torpedoes.

Some authors do not believe in a fundamental formation for battle, but think that any formation in which the fleet presents the bow to the enemy may be taken as an order of attack.

Admiral Penhoat says that vessels composing the line-of-battle must steer the same course, or they will run the risk of collision. In his opinion, if the plan of action is based upon artillery, the best formation is simple line ahead, steering a course as nearly as possible a right angles to the direction in which the enemy bears; otherwise the broadside guns could not be used.

Even with the ram as a basis of attack, some authors prefer a line ahead on a course perpendicular to the line of formation of the enemy. Their reasons being: first, that each ship in line ahead can as it cuts the enemy's line use both broadsides; and, secondly, the rear vessel of the line can, without interfering with the other vessels, take advantage of the *mêlée* by the time it reaches the enemy's line, and use its ram to advantage. They consider, in making this departure from rather well-established ideas, that vessels nowadays have such great speed, and that artillery, from its size, must be so slowly served, the leader of the line ahead will not be punished so badly as formerly. Another advantage of this formation for attack is, that the rear vessels are protected. the strongest and most formidable ships leading into action.

Mr. Besson says that line ahead is the easiest to keep or to reassemble in. It is perfectly flexible, and can in a few minutes change to any direction. Each vessel is flanked by the next astern which can come up on either side. The vessels being in the wake of one another must maintain the same speed, it is true, but by sheering to either side any vessel can take up any speed, or use its turning power in any way. The artillery fire, for the broadside, is entirely unobstructed, but the ram, the bow and stern fire, and the torpedoes are certainly put out of action, but by a slight sheer out of the line any or all of these weapons are called into play.

This formation fulfills all the requirements of a good fighting order.

In line ahead, in close order, the vessels flanking each other mutually, and their broadsides protected by auto-mobile torpedoes, the formation should be nearly impenetrable. The last ship in the line is the only exposed one, and she should be endowed with excellent turning qualities.

The line ahead presents, according to circumstances, either the bow or the broadside to the enemy. At a distance, using artillery, this formation is most efficient with a broadside presentation. It would be foolish to engage the enemy broadside to, near at hand, as the fleet would be too much exposed to the enemy's rams and torpedoes.

Captain Grillo, of the Italian Navy, adopts, as an order of battle, the line ahead steaming at right angles to the enemy's front. The formation should be kept up as long as possible. He re-enforces the head of the line with the reserve division, and the rear of his line with rams or ram-bowed cruisers. (See Plate XVII, Fig. 4.)

On the other hand, Admiral Randolph expresses the opinion that the line ahead is a bad attacking formation, for the reason that only the leader can ram, all the guns of the fleet are not used, and because the ships do not mutually support one another to any degree. He says, "It is fraught with the maximum of danger."

Mr. Laughton remarks, "The best professional opinion refuses to admit the line ahead as an attacking formation."

The formation in alternate lines ahead, according to this writer, is free from the defects of the single line, but it is still too extended. A concentrated attack on the rear might inflict fatal damage on one or two ships, before the van could come round to their assistance, supposing that the enemy's formation had been penetrated by a portion of your line.

The alternate line ahead, however, has certain advantages. It is powerful as regards fighting the battery, and permits vessels of the second line to ram vessels of the enemy penetrating the first. Another author says that a formation in alternate line ahead permits a squadron to preserve a good battery front. It is a formation hard to break through and has little to fear from rams. It has the drawback of not being flexible.

The majority of tacticians are of the opinion that the most reliable formation for attack based upon the ram is founded on the line abreast; still it has several alleged disadvantages, which are as follows:

1. It is hard to preserve the dress of the vessels.

2. It is so extended as to favor concentrated attacks of the enemy anywhere on the line.

3. The Admiral's signals will be hard to make out by vessels on the flank.

4. The flanks are unprotected.

5. It precludes broadside fire, except from the wing ships, which are unsupported.

6. It is not flexible. Changes of direction require long and difficult conversions.

7. It is the easiest formation to break through and to break up, if the enemy, in one or two columns, concentrates every effort on one point.

These disadvantages are discussed by Mr. Besson, and some disappear under the light he throws upon them; for instance, it will be shown later, in discussing the "Fleet in action on the open sea," that the broadside fire *can* be used, without endangering the other vessels of the fleet, at least at any period subsequent to the first charge.

In regard to this formation not being flexible, it is thought that if this order was formed just a little while before it was needed this inconvenience would disappear.

Mr. Besson calls into question some of the charges made against it, and says that if there are no more than eight ships in line, the formation, being simple, is consequently easy to maintain and to retake, and, furthermore, in it, the vessels mutually give one another the maximum of support. It is considered at the present day the best attacking formation for rams by the French writers, and by many foreign ones.

In regard to exercising in this formation, the rule is laid down that the vessels should be the radius of a turning cricle apart. Each vessel then has control of its engine and helm, and may be said to be unobstructed in its movements. The torpedo and ram can be perfectly used, likewise the bow and stern fire.

Vice-Admiral Bourgois and Lieutenant de Penfentenyo believe that the attack should be made in line abreast, but that after the first charge the formation will disappear; Admiral Bourgois believing after that instant each vessel will act for itself, while Mr. de Penfentenyo advances the opinion that the fleet should form groups, and lays down rules for so doing.

Mr. Besson says that two lines abreast, either double or alternate line abreast, is preferable to single line abreast. It has the merit of concentration and mutual support. The heaviest ships should be placed in the front line, although they may be hampered in the use of their rams and torpedoes, to some extent. In this formation there is this drawback, that it is hard to change the vessel's course sixteen points, which must be done after passing through the enemy's line, to charge him again on account of possible collisions with vessels in the second line.

Admiral Penhoat acknowledges that this is a hard formation to keep in, but he says that its disadvantages are few, and that any error in dress is easily rectified, agreeing, as we see, with Mr. Besson on this point.

Captain Fremantle is of the opinion that if there are many ships, the fleet should be divided into independent squadrons, but preserving for each squadron the formation of alternate line abreast. On the other hand, when your fleet is so small as to allow the enemy's line to overlap your flanks, when formed in this manner, Mr. Besson says that you must not fight in this formation, but in *single* line abreast.

Captain Attylmayr does not believe in the double or alternate lines abreast, and says that it should be entirely discarded as an attacking formation.

According to Captain Grillo, in attacking this formation with a fleet formed in line ahead, the rear vessels of your line ahead should be ordered to reserve their fire for the rear line of the enemy's two lines abreast.

The great drawback to the formation in square is that stations cannot be maintained at good speed.

Formations *in échelon* present to the enemy a line of rams and a line of fire. Yet it is a dangerously bad formation if it is attacked in direction of its line of bearing, as it is not flexible. An angular formation, such as a chase formation, permits the use of only one broadside on the enemy; moreover, it is a hard formation to maintain, and an attack from rams is liable to get it into confusion. Although a formation in chase-angle gained for the Austrians the battle of Lissa, its disadvantage is in changing direction. The point of the angle must be kept towards the enemy, otherwise the enemy will concentrate on one of the flanks. Owing to its unhandiness as a general formation for attack, it is not to be recommended. In fact the most modern tacticians condemn it entirely as too clumsy. Unless the enemy, in some simple formation, was very badly managed he could turn so that he could always avoid the point, and could thereby flank the fleet.

Captain Werner, of the German Navy, in 1873 said, that "all modern systems must look to the ram as the main weapon, and all formations should have this end in view, and should try and combine as many rams as possible on the enemy at the point attacked. To do this the fighting formation should be such a one as to remain intact and be compact as long as possible, and at the same time to permit of great mobility. The group system of three vessels is the only one which satisfies these conditions. It is easily managed and can be rapidly formed again on dispersion." Captain Werner believes in the right-angled triangular group, hypothenuse to the rear. Other friends of this system argüe for the scalene triangle, since the rear vessel has an excellent chance to ram. They all believe that after the fight commences every group should be under the sole control of its leader.

Lieutenant Campbell arranges his groups in a manner that has the advantages of the unity of the group system, and the defense and support accredited to the double or treble line abreast. (See Plate XVII, Fig. 5.)

Line ahead by groups, in one or two lines, appears to Lieutenant Algranati to fill all the conditions of an excellent order of attack. The first or second charge will break up any elaborate formation, and the groups will probably hold on longer to their identity than ships in any other formation. The leading groups should be formed with the most formidable armor-clads. The rear group, which has the best chance to ram, should be composed of those vessels best qualified for this work.

Vice-Admiral Randolph examines, in his work on tactics, the different formations that a squadron can take to attack, and he proposes an order in *échelon* on a line of bearing not greater than one and a half points forward or abaft the beam. He applies this formation to eight armor-clads divided into divisions, and he places them on two lines of bearing, but one line is the inverse of the bearing of the other. They are formed something like a retreat formation. (See Plate XVII, Fig. 6.) After the first penetration of the enemy's line, the order of cohesion ought to be kept up until the squadron has executed the plan of battle of the admiral. After this the greatest liberty of action is left to the captains.

An authority who favors this system of Admiral Randolph says—

> We think that it will be always wiser and more advantageous to keep together all the forces in a compact mass than to divide them into isolated groups. If the aim of strategy is to deceive the enemy to the last moment, to hide from him the method of attack, we believe that this result can only be brought about by rapidly moving the squadron *en masse*. We conceive this can best be done by using some flexible preparatory formation, and then moving in some preconcerted manner, as contemplated by Admiral Randolph.

The retreat formation as a formation for retreat or otherwise has few friends, and may now be considered obsolete. Any spread-out formation, such as this is, is bad. In retreating the best formation is probably in lines ahead, with the least-injured ships nearest the enemy. Authors who recommend spread-out formations to serve this purpose forget the following considerations: A spread-out order supposes that all the vessels can steam without assistance, and are still in a condition to fight. This hypothesis is not tenable, for a fleet would retreat fighting, and only after a reverse or failure. On its face a spread-out order permits an enemy with superior speed to concentrate its force on some point of the fleet in retreat, and destroy it.

In alternate lines ahead the formation is more concentrated and cohesive. Every gun is capable of being used against the enemy. Stations are easily kept, and the towed vessels are well protected. Finally, there are no complicated maneuvers. So this formation is the best for disabled vessels in retreat, as they can be taken in under the guns of their own fortifications, or can enter their ports without any evolution, save changing direction.

Possibly there is one condition where retreat formation may be available; that is, when fighting in a comparatively narrow channel, there is danger of being attacked by the enemy's fleet.

CHAPTER VIII.

EVOLUTIONS OF THE FLEET.

I.

Evolutions in naval tactics have for their object the assembling of formations and the passing from one formation to another. They must satisfy the following requirements:

1. They should be done in the least possible time.
2. They should be spread out as little as possible.

There are three methods of evolution; those controlled by—

1. Simultaneous movements.
2. Successive movements.
3. Direct or oblique movements.

It will be seen further on that some tacticians draw a line between *direct* and *oblique* movements; others consider this extreme delicacy of division to be unnecessary.

The tactician should study these fundamental movements thoroughly, so as to decide *without hesitation* which method fits the case best. It will be seen that some evolutions require a combination of all three of these methods.

Evolutions are not tactics, although they form the basis on which tactics are founded. Captain Fremantle says, "they are simply fleet drill, and the signal-book is the drill-book."

In all evolutions performed by a fleet at sea in the presence of an enemy, the one important point is that they should be quickly understood by the commanding officers of the ships composing the fleet. To attain this very desirable result, it is necessary, according to Lieutenant Campbell—

1. That the signals should be as few in number as possible.
2. That the explanation attached to each signal should be as explicit and concise as possible.
3. That the officers of the Navy should be instructed in the manner of performing the maneuvers as early in their career as possible.

Since changes in naval warfare are constantly rendering changes in ships necessary, changes in ships bring about changes in evolutions and also in the manner of performing them. These changes necessitate changes in the signal-book.

The knowledge of the helm, the speed of the ship, and the elements of the turning circle, certainly furnish the basis for all evolutions. There will be some difficulty in maneuvering a fleet composed of vessels varying greatly in speed, turning power, and armament, so as to develop the special qualities of each ship; therefore it may be set down as a maxim that the actual capabilities of the worst of the vessels comprising a fleet must be taken as the representative capability of such fleet. So that the maximum speed of the slowest ship is effectively the maximum speed of the fleet, and the circle of the ship which describes the largest, is, effectively, the circle on which every vessel in the fleet has to maneuver.

It seems, therefore, to follow that the power of a fleet as a fighting unit may be improved by the rejection of those vessels whose power of maneuvering is bad. Mr. Laughton says: "Ships so ejected might form a reserve to act in time of battle, independent of the formation of the main body."

It must be borne in mind that a surprise to a fleet by an enemy has ever been dangerous; but with our modern means of warfare it will certainly prove disastrous. This being the case, it will require great foresight on the part of a commander-in-chief to have his fleet in such a condition, as regards formation, that it will not be necessary to perform any evolution of moment in the presence of the enemy. Should it become necessary, however, under these circumstances, to maneuver the fleet in order to form to resist attack, such an evolution must be performed by *ships*, according to Admiral Penhoat, and not by *groups;* as by this latter system the fleet will be spread out, and a concentration on a portion of it by the enemy will be easier. The Admiral goes on to say that—

> If the form and organization of the line-of-battle are well determined, it will be easy to deduce the proper formation for steaming and to establish in some way a proper system of evolutions. These evolutions, above all, must be simple.

It may be laid down as a general principle that no evolution is of merit which employs such a method, to pass from one formation to another, as breaks up the mutual support which should exist, in all good tactics, between the ships of the fleet.

After preparatory exercise, so as to permit the captains to familiarize themselves with the handling of their ships, the fleet should be formed in line and exercises should begin. We have before discussed the principles by which the speed and position are maintained, and have given forms of the tables to be used.

The fleet must drill at making together two turns of 90° each: one turn with the helm one way, and the other with the helm over the other way. The turns to be made at full speed and to be continuous. (See Plate XVIII, Fig. 1.)

Drill in change of speed can be done as follows: The fleet being on a line of bearing four points on the Admiral's quarter, for example, and on the same course as the flagship, will, at the signal, come into line abreast, dressing on the flagship. Then the moving flank will be changed, and the same movements will be repeated, pivoting on the ship on the other extremity of the line. The ships always steering parallel courses.

Night drill is simplified by the improved methods of electric lighting. It certainly takes more nerve to drill in darkness, but it is most necessary, and the Admiral should constantly exercise his fleet at this time.

In regard to intervals, the general rule is to close them when the formation is accomplished, and to open them out before beginning to form a new one.

Owing to the reduction in speed caused by turning, vessels changing direction in line ahead in close order will be likely to collide with the next ahead. Distances then must be great enough to permit vessels to turn without being run into.

The following instructions taken from the "Manuel du Matelot Timonier (Paris, 1882)" are extracted from the first volume of the Naval Tactics of the French Navy:

GENERAL PRINCIPLES FOR SQUADRON STEAMING.

Every vessel which increases or diminishes its speed must communicate the fact to the next ahead and the next astern.

This rule not only applies to formations and to evolutions, but to every circumstance where vessels maneuver in proximity to any others. It is shown by hoisting the speed pendant higher when the speed is increased, and lowering it when the speed is diminished. At night a lantern is waved over the bow, to be answered by the next ahead, when the speed is increased, and if the speed is diminished, the lantern is waved over the stern, to be answered by the next astern.

The only circumstances under which a vessel is authorized to stop, when steaming in squadron, are the following:

1. To save a man overboard.
2. In case of an accident to the engine, screw, or rudder.
3. To avoid a collision.

In almost every case the vessel which stops should drop out of line, by sheering to that side which interferes with the other vessels the least.

II.

In any movement made by a fleet in performing an evolution, there are the following requirements to be fulfilled: /

1. To lose as little distance as possible in passing from one point to another.
2. To avoid any possibility of collision between two or more ships of the fleet.
3. To keep the fleet in such a condition as to form order-of-battle easily and quickly.

We may also state that the nature of all movements of a line-of-battle presents three phases:

1. To approach the enemy—bow towards him.
2. To keep at a certain distance from the enemy—broadside towards him.

3. To retreat, or increase the distance from the enemy—stern towards him.

We have said in the first part of this chapter that movements may be classed under the head of simultaneous, successive, and direct.

SIMULTANEOUS MOVEMENTS are those performed by all the ships of the fleet, which are steering the same course, coming together on some other common course.

SUCCESSIVE MOVEMENTS are those which are performed by means of the *countermarch*. This method consists in putting the fleet into line ahead. The leader steams in the new direction, followed by the other vessels. The advantage is that it requires no signals, the quickest speed is maintained, and there is little or no danger of collision. Furthermore. a countermarch is applicable to any number of vessels, whereas, a *wheel in a concentric circle*, which is intended to accomplish the same object as a countermarch, can be undertaken by only a very small number of ships. since the greater the radius of turn for the fleet or squadron in line abreast, the greater the speed to be made by the moving flank ship. With more than five ships in line, the flank ship would have to make greater speed than vessels are generally capable of doing. There is a method called by the French *conversion*, which is intended to accomplish the same object as the wheel or countermarch, and which is a combination of the simultaneous movement and the direct movement. This method will be further discussed at another point in this chapter.

When the movements refer to changes of direction of eight points by means of a successive movement, they are termed "rectangular movements," and evolutions performed by this method furnish the basis of a regular school of tactics. There is another method of performing rectangular movements, now practiced in the French evolutionary squadron, we believe, which resembles the *isodromic* method of Captain Lewal, which will be touched upon later.

Without discussing *all* the plans, methods, and means of evolution suggested in the last twenty years, we will say the great speed that ships are now capable of, and at which all evolutions must be performed, entail upon these evolutions the greatest possible simplicity. Therefore it may be laid down as a general rule, that where direction is to be changed without changing the formation, if the angular difference between the new and old line of bearing is less than four points, and if the fleet is in line abreast and not very large as regards numbers, then wheeling in concentric circle or conversion should be resorted to. If, however, the change is greater than four points, then the evolution will be performed either by a simultaneous movement into line ahead, followed by a countermarch, and then again swinging simultaneously to some common course, or the evolution will be performed by a DIRECT MOVEMENT. A direct movement is where each vessel proceeds from her place in the old formation to her place in the new, at the quickest speed, by the shortest route, without reference to the other vessels of the fleet. Since one of the vessels of the fleet is formed upon in all direct movements, and since vessels arrive in their new positions at different times, changes of speed are necessitated. Simultaneous and successive movements, then, have this advantage over direct movements: full speed can be maintained at all times.

Although at first glance the direct method may seem to be the easiest to maneuver in, it is not so. Unless the fleet is very well drilled, there is great danger of collision; and, moreover, the vessels in passing from one point to the other are in no formation and are therefore at a disadvantage in case of attack.

Captain Fremantle thinks that it is "wise to prescribe as closely as possible to each captain the course to be followed." He also thinks that there will never be an attempt made to change a formation when in action, since such change will act too disadvantageously for the fleet in the manner we have spoken of. Furthermore, he says: "Rectangular movements, which allow changes of formation to be made without variation of speed, are correct."

Many authors, however, do not believe that rectangular movements are applicable to a fleet of armored vessels, into which fighting by means of the ram enters. They believe in direct movements, which, as we have before said, contemplate a vessel proceeding from one position in a formation to some other position in some other formation by any route her captain may chose, observing the usual rules of the road.

Some writers favor the use of both systems, the admiral to be governed by the environment as to which method he will use. Each of them, however, have their drawbacks. With rectangular movements, if we are maneuvering in the presence of the enemy, our broadsides are exposed to his line of rams; with direct movements collisions are liable to occur, and the fleet is without order until the new formation is complete.

An advantage with rectangular movements is that it takes less time to perform the evolution, and the location of the new formation is exactly known; that is to say, the commander-in-chief, supposing him to be in the leading ship, passes exactly over the spot of the new line of bearing; whereas with direct movements it is not so. For instance, the fleet are in line ahead, and they wish to form line abreast on the leader, on a line of bearing eight points from their present line. As the leader must keep up his steerage way, although at a reduced speed, say four knots, the consequence is that by the time the fleet are in line abreast the formation is accomplished two or three miles ahead of where the leader was when the evolution commenced.

With the great speed that vessels will maneuver at nowadays, it may be set down as a maxim, that, if an enemy's fleet should be discovered less than four miles off, and your formation was in line ahead in direction of the enemy's bearing, and you wished to form line abreast, or some modification of it, you must use a rectangular, and not a direct movement; otherwise the enemy will be upon you before your formation is complete.

A point in favor of direct movements is, that ships performing this evolution always present their bows to the enemy, which, in this age of ram warfare, is of great moment.

III.

It is our intention now to consider several systems proposed by tacticians for the performance of evolutions. Many of the methods presented are perhaps antiquated, still they are so often referred to by later writers that it will be as well for us to make some little examination into them.

We have seen that Mr. Laughton divides his fleet into groups of three; each group he terms a squadron, and each leader is the flagship of a rear-admiral. His method of evolutions consists in putting his squadron into line ahead, and using a successive movement, or in putting each squadron into line abreast, and making a wheel in a "concentric circle" through eight or sixteen points. To these are added simultaneous movements, which may be considered as entering into the scheme of evolutions of every tactican. Mr. Laughton also bases his evolutions upon a time element so that a ship, for instance, in a formation in line ahead in close order puts over her helm at a certain time-interval after she has received a signal from her next ahead. When this last ship puts over her helm she signals the fact to her next astern, &c.

The author describes his method of performing concentric circles, as follows:

> At a reduced speed of three knots, the pivot ship describes the arc of her circle through the required change of bearing; the center ship describes the same arc with a double radius, at a speed of six knots, and the third ship with a treble radius, and a speed of nine knots, thus "wheeling" into line on the required bearing.

We have here a simultaneous-direct movement, but with two new elements; helm angle different for each ship and different speeds.

Commander Noel adopts groups, as units, performing rectangular movements. That is to say, all movements made by groups are to be considered, when maneuvering in fleet formation, as if the groups were each a single vessel. Among the vessels of the groups themselves the movements are *not rectangular*, and are made at different speeds. The speed of the group-leader, however, is never changed; always being the highest adopted speed of the fleet. The movements of the fleet are, nevertheless, rectangular when passing from one distinct formation to another.

Captain Fremantle remarks substantially as follows, on this point: The difficulty of evolutions in groups consists in this: The ships of a group must maintain both their relative and absolute bearings—that is, when the course is changed, the whole group have to swing into their new positions as ships forming on their group leaders in order to keep up the formation. This involves so many difficulties, as change of speed, &c., that all advantage of the group of three ships is lost by its unhandiness.

Vice-Admiral Jurien de la Gravière, who commanded the French fleet of evolutions in 1868–'70, chose the division as the tactical unit, and had the following ideas upon some tactical questions. He did not believe in any fundamental formation for attack. The battle having once begun, the captains must fight the ships without any special direction from the Admiral. Furthermore he did not believe that rectangular movements were suitable for armor-clads, and therefore he substituted those which were direct. Every vessel proceeded to her station as we have before described, and for which maneuver an expression was invented, or at least a phrase was applied, namely, that each vessel should "*chasser son poste.*"

Admiral Boutakov takes as a point of departure for his evolutionary system, the idea that every evolution of a vessel is formulated upon two geometrical lines: the circle, and a line tangent to it. Considering the vessel to be moving, if the helm is put over she describes a curve, which may be taken as a circle, and if the helm is righted she describes a line which is tangent to this circle.

The radius of the turning circle used by the squadron is the basis of all measurements, and everything is laid down with the greatest precision. He contrived a series of co-ordinates, so that the ship at any movement of its evolution could be plotted mathematically. Probably it is more theoretical than practical, for although each captain is furnished with minute *data* as regards engine and helm, still the author supplements these instructions by advising the commanding officers that they must be governed also by surrounding circumstances, and that they should preserve their stations by viewing the situation rather than by a blind following of theory.

The Admiral indicates several methods of changing the direction of a line ahead. Some are made by countermarching and some are made by conversion. This last evolution is made in three movements.

Wishing to change direction eight points, being in line ahead—

1. All the ships together put over their helms and swing to a line-of-bearing parallel to the course in line ahead. The angle which the head of each ship swings through is always once and a half, the change of direction of the lines of bearing. (See A, Plate XVIII, Fig. 2.) In this case the ship's head has changed course through twelve points.

2. Each vessel proceeds at different speeds, the pivot vessel just turning over, the flank vessel moving at full speed, dressing on the pivot ship, until the line of bearing is changed eight points. (See B, same plate and figure), when;

3. Each vessel puts its helm over simultaneously, and swings into line ahead. (See C, same plate and figure.)

2. When the change is greater than 60°.

In the first category the positions of the ships do not change; the leader remains ahead. The vessels on his quarters move in such a manner that each ship brings itself to bear half the angular change with the new course, the ship on the starboard quarter slacking speed if changing course to starboard, the vessel on the port quarter increasing hers. (See Plate XX, Fig. 2.)

If the change of direction is more than 60°, the three vessels come together on the new course at the same time. The vessel that finds itself *leading* in the new direction becomes *the leader;* the two other ships so use their speed and helm as to group themselves as shown in Plate XX, Figs. 3 & 4.

When a change of 16 points is made, the triangle is reversed by the method shown in Plate XX, Fig. 5.

We now come to consider the evolutionary system of Admiral Penhoat. He is very minute in his discussion of evolutionary points, and it is to be regretted that his most interesting instruction cannot be more fully entered into in these pages. Both the successive and direct systems are used by him. As regards simultaneous movements, he says:

> Theoretically, in these movements every ship puts its helm over in the same direction at the same time; practically, the ship that has no vessel on the side towards which she turns should commence—as, for instance, the rear ship in line ahead; as soon as the maneuver is marked, then the next ship to her, and so on.

The signal for the execution of any evolution may be given by the steam-whistle of the flagship, as well as by hauling down the hoist of flags.

Simultaneous movement is the only method which can be used in action.

Successive movements relate to the maneuvers of a line ahead, when one vessel keeps its station at all times in the wake of another, its next ahead, no matter what change of direction is made. In changing direction, which in successive movement is for each ship only a change of course, each ship moves her helm over easily. (See Plate XX, Fig. 6.)

In regard to direct movements, this expression designates, as we have said, a maneuver of a line which passes from one formation to another by each vessel steering directly for its new position; for example, being in line ahead, to form line abreast. (See Plate XXI, Fig. 1.) The pivot vessel reduces speed to steerage way and continues on its course. The other vessels steer sufficiently to port to gain their stations at full speed first; then, moderating their speeds and keeping their dress, on bringing the pivot guide on a proper bearing, they will steer his course. Suppose the pivot's speed is five knots, and that the rear vessel gains its position at the rate of 11 knots, it would take a fleet of eight ships twenty minutes to perform this evolution, and the formation would be completed 2 miles from where the evolution commenced.

If two opposing fleets have each a tactical speed of 11 knots, it will be necessary to begin the formation for attack 6 miles about from where the enemy is, in order that it may be accomplished by the time you must engage.

We will compare this with an example of an evolution composed of a successive movement succeeded by a simultaneous movement, being in line ahead, to form line abreast, changing direction eight points to starboard. A successive movement is made eight points to starboard, and when the new line of bearing is reached by all the vessels of the fleet, a simultaneous movement is performed eight points to port. It will take eight vessels, 300 yards apart, steaming at a rate of 11 knots, ten to thirteen minutes to perform this evolution. Advance, say, 200 yards.

In the first part of this chapter we said that some tacticians discriminate between *direct* and *oblique* movements. Admiral Penhoat, as we will see, makes an oblique maneuver a subordinate division of direct movements. He says, "That category of direct movements which is the most unfavorable is where the line abreast to be formed is at right angles to the line ahead you are in, and which we have discussed. If this line abreast is *oblique* to the line ahead, the consequences of the movement are not the same." Let us suppose a line ahead of eight ships, distance 2 cables, speed 10 knots, are maneuvering to form by a direct movement a line abreast, where the line of bearing is at an angle of 45° with the old line. This is termed an *oblique movement.* (See Plate XXI, Fig. 2.) It is done as follows: Simultaneous movement to starboard from line ahead, through the angle which is the complement of the angle which the new line of bearing makes with the old. Each ship then steers for its new station in line, regulating speed as in former cases. If we suppose the speed to be the same as in the example of direct movements, it will take fifteen minutes to complete the evolution, and the fleet will have run 2,000 yards on its course. It would take a little less time to make this same evolution by countermarch. The rule is, if the change of the new line of bearing is more than an angle of 45°, use successive movement; if the angle is less than 45°, use direct movement.

Direct movements, when the fleet is formed in double line ahead, with an interval equal to a divisional front *plus* one distance (see Plate XXI, Fig. 3), present some advantages over successive movements, if the fleet wish to form line abreast. With eight vessels steaming 10 knots, and preserving the usual distance, the duration of the evolution will be eight minutes and the gain ahead three-quarters of a mile. With a successive movement the duration would be nine minutes. If the line abreast to be formed is not at right angles to the double line ahead, the movement is not so simple, but it can be done in two ways.

The first method (see Plate XXII, Fig. 1) is to form line abreast by a direct movement, then change course eight points, coming into line ahead. Enter on the new line of bearing by a successive movement, and then, when the fleet is on this line, all come into line abreast.

The second method (see Plate XXII, Fig. 2) is to form the fleet into line ahead by a successive movement on a line eight points from the old direction, then steer in the new direction, and when the fleet is on this bearing come into line abreast simultaneously.

We now come to consider change of direction of vessels in line abreast or on a line of bearing by certain direct movements generally called *conversions*. *Circular conversions*, or *wheeling in concentric circles*, is, as we have seen, impracticable for a large fleet, on account of the speed demanded from the vessel on the moving flank. The author explains the following system as an efficient substitute or modification. A conversion becomes constantly necessary as the bearing of the enemy changes You desire to keep your line parallel with and opposed to his. (See Plate XXII, Fig. 3.) The fleet is on line A, and you must change to line B, as the enemy has changed his position from C to D. To do this the vessels come simultaneously to a course perpendicular to the new line. The pivot stands on with barely steerage way; the flank ship stands on with the fastest speed. The rest of the vessels vary their speed to keep their dress. When they arrive on the new line B, speed is resumed. This is not strictly a good method, since it brings the ships closer together on the new line. It, however, answers very well for small changes of direction, as it takes the least possible time to perform such change. If time offers after this evolution has been performed, the fleet should open out to their proper distances.

In order that ships should be at a proper distance from one another when they arrive on the new line, they should steer such a course from the old line A (see Plate XXII, Fig. 4) as to be perpendicular to a line bisecting the angle between the old and the new lines of bearing.

The Admiral has the following to say on formations, and the peculiarities of naval war that are now forced upon us by the enormous speed made by ships. Even with a small number of vessels, no movement can be made with the enemy bearing down upon you, inside of four miles separation. If an evolution *must* be performed, it would be better to charge through the enemy's line, in the formation in which you happen to be, and form on the other side. You have been caught at a disadvantage, and you must make a run for it, and this is the safest way to gain time to perfect a formation.

We have now presented about all the principles involved in the evolutionary systems of the last twenty years; only those in future will remain which fulfill the following conditions:

1. The ships must cover the least space at full speed without danger of collision.
2. The evolution must be feasible at night as well as by day.
3. During the evolution the ships must be formed, and be able to give each other mutual support.
4. If possible, the broadside must not be presented to the enemy's line of rams.

It may be judged from our previous remarks on formations that only lines ahead and lines abreast have survived the necessities exacted of tactics by the modern ship. The only question, then, is, what evolutions permit these formations to be accomplished under circumstances of ordinary steaming or in the face of the enemy? The fulfillment of the first three of these conditions imposes simultaneous and successive movements; the fourth category renders, under some, we may say most, circumstances, direct movements necessary.

The ideal system of evolution has yet to be perfected, but we are inclined to believe that it will be founded upon the *isodromic* method. It may be said for this system that when a fleet is maneuvering in the presence of the enemy, each vessel is pretty well covered by the remaining ships from any onset of the enemy for purposes of ramming.

CHAPTER IX.

THE FLEET IN ACTION ON THE OPEN SEA.

I.

In the opinion of a German tactician, the naval battle of the future will bear some resemblance to a combat on shore. In the army long lines of skirmishers are pushed forward, followed in quick succession by other lines, until the whole force is deployed, when the whole body advances, and in a few minutes the battle is decided. His idea is that the torpedo vessels represent the lines of skirmishers, and the line-of-battle ships the columns.

Captain Rivet says:

> The following tactical directions may be considered fundamental:
>
> 1st. During the execution of a maneuver determined on beforehand or ordered by signal, and which has for its object the bringing of the fleet into action, no vessel must change course except to avoid being rammed.
>
> 2d. From the moment that the fighting formation is broken up the combined action of the vessels as a fleet will cease. Each ship must act by herself, and she should try and avail herself of every chance of ramming the enemy which presents itself, and should assist any friendly vessel in need.
>
> 3d. Mutual support would point out the necessity of not separating. The grand object will be to keep together, and prevent the enemy from concentrating on any point.
>
> 4th. When once the ranks are broken it is imperative to keep a lookout on the flagship for signals, although the fighting of each ship as an individual must not be relaxed.

Captain Bridge, R. N., remarks as follows:

> Fleets will approach one another at a greater or less speed; that of about 8 knots, I am inclined to believe, will be the most usual. As they approach, every gun will be, most likely, fired. As they arrive in close proximity, the bow-gun fire will become at length ineffectual, and the respective captains will be disinclined to keep the fore parts of their vessels enveloped in clouds of smoke; so it will cease. Now will come the doubly-anxious moment of seeking to ram one's antagonist and to avoid being rammed by her, to steer clear of towed torpedoes and to plant one's own torpedo conveniently under her water-line. In the early stage of an action I venture to think no great damage will be done on either side. The two, I expect, will pass through one another to a great extent intact, till there shall arrive the time which shall be the crucial test of the value of the evolutionary practice in peaceful times. The two fleets will have to re-form! Picture to yourself the effect, moral as well as material, of a well-ordered column of fresh ships bearing down at superior speed upon a group of vessels endeavoring to re-form. This strictly tactical movement (that of bringing an overwhelming force upon some portion of the enemy's fleet) should not be left to chance or signal.

Mr. Laughton, in his "Essay on Naval Tactics," expresses the opinion that firing between vessels and fleets on the open sea should only be at very close quarters, and says:

> Men at all times are too ready to throw away their ammunition at extreme ranges. In naval action premature firing can have no other effect than to raise a cloud of dense smoke, through which signals cannot be seen, to put an early end to all precise maneuvering, and to let the ensuing fight become a mere scrambling rally, decided, as at Lissa, by individual dash, backed up by good luck.

Although individual dash is not only a valuable but a necessary quality for an officer to possess, still method is of more moment. An eminent tactician says:

> A squadron moving on an enemy must do so in some order; an advance as a mob means defeat. Individual dash is inferior to system, even should that system not be the best.

The following conclusions may be drawn from the expressions of opinion of many writers on this science:

Plans of battles should be prearranged, so that when the enemy heaves in sight he can be attacked without numerous signals being made.

The enemy should be attacked, if possible, if he attempts to pass from one formation to another.

Guns should be fought trained nearly abeam and concentrated fire used. The guns should be fired generally by broadsides, and at a range of about 500 yards.

The ram should be freely made use of. It should be considered the principal weapon of the ship.

Torpedoes should be used preferably by special steamers, but all vessels must be fitted to use some type of this weapon.

We have seen it is the intention of the writers upon this science, whom we have quoted, to use the torpedo-launch or the torpedo-boat, which may be carried by the ships of the line on the high seas, to do their torpedo work during an engagement. It occurs to us that tacticians may well pause and consider the possibilities which surround the plans which they advocate. Will not the lowering of torpedo-boats just previous to an engagement be fraught with danger, by giving the enemy a chance to concentrate and ram you? To get the boats into the water, speed must be reduced, your line will get out of dress, your attention will be distracted from the main object—the attack—and the probability will be that *all* the torpedo-boats will not have sufficient steam, cannot organize, and will fall an easy prey to an alert enemy. Perhaps, to gain your stations and to make your attack in a proper formation, you will have to leave your boats bobbing about a mile astern—of less than no use. If the enemy is sighted, and you have your boats on board and you intend to use them, it would be better to form in retreat, take your time to get your boats overboard, and when all is ready, and your boats have formed between you and the enemy, change course sixteen points upon signal and stand into action.

II.

Regarding the most useful formation for fleet combat, circumstances can alone decide whether it is better to form the fleet in one body with detachments acting by themselves, or whether it is best to divide the fleet into two main divisions acting independently, and attacking the enemy in two different directions at once. It will depend upon the relative numerical strength of the two fleets, as well as on the nature and the power of the vessels comprising them.

The following remarks are made by Captain Rivet in his discussion of attack formations:

It would be well for the most numerous fleet to divide into two main bodies, and one should act to cut off the retreat of the enemy. This portion should be strong enough to stand the brunt of an attack from the hostile fleet should the enemy succeed in outmaneuvering the other portion of the fleet. If the two fleets are numerically equal, the fleet should act together as a unit.

Rear-Admiral Aube, in his essay, further says:

> It seems to be admitted that an action will commence by a primary general attack, a collision between opponents, ship to ship; the fleet being formed in an order for which can be laid down no absolute rule.

Each vessel must keep its bow to the enemy to prevent ramming. The formation will be then one of two classes—great width with little depth, or narrow front with great depth. In other words, the only formations for modern fighting are the line ahead and the line abreast, and their derivatives.

In regard to concentration, we draw the following ideas from Admiral Penhoat's work:

The mode of concentration differs for whichever arm of warfare is put into action. There are three methods for concentrating in artillery engagements the batteries of a certain number of your vessels on a smaller number of the enemy:

1. By oblique pointing.
2. By the passing of the fleet before the one point assailed in the enemy's line in line ahead.
3. By catching any ship or ships of the enemy between two fires.

This last method of concentration consists in penetrating the enemy's line, to take between two fires each of the vessels of that portion attacked. The fight should take place at close quarters. This system of warfare leaves a portion of the enemy's fleet out of the fight, which will seek to enter the *mêlée;* but if the concentrating movement has been quickly executed before the unattacked portion of the enemy has had time to get into action, a decisive result should have been attained.

Considering the question of concentration in regard to rams, two rams cannot well attack the same vessel at the same instant; still, the two can act in concert, either on the same broadside of the enemy's ship or one on each side. In each case the attacked ship should endeavor to bring about a collision between its assailants.

The attacking vessels should ram the enemy's ship one after the other; therefore, any number of vessels can be concentrated for ramming on one of the enemy. In artillery concentration, however, only two, or at most three, ships can be used against one of the enemy.

Concentration for torpedo attack resembles somewhat the method used for ramming. If the torpedo is carried ahead on a spar or installed to act right ahead (if of the auto-mobile type), the methods are identical.

Mr. Campbell has to say, in regard to this most important factor of success—concentration:

> Had I a fleet of twelve ships in action against a fleet of twelve ships of the enemy, I would do my best to maneuver so as to fight them one at a time, or "twelve to one," and failing this, two together, and so on; last of all would I fight the twelve at the same time—that indeed would be a *dernier résort.*

III.

The following remarks and general rules applicable to actions between fleets are drawn from various sources, and may be considered as conclusions formed by the best tactical writers.

An attack upon one fleet by another, in fact the whole combat, will consist of a series of rapid penetrations of the enemy's line. Each side will be equally an attacking party. After the first charge all fleet combination will cease, and vessels must act for themselves. The ship then becomes the tactical unit. In all charges, having once passed through the enemy's line, it must be well understood beforehand how the vessels are to turn, whether to starboard or to port. This should be governed by an inflexible rule. If it was arbitrary, confusion and disaster would certainly follow.

In opposition to those who think it better for a fleet approaching an enemy to have the wind aft, so as to drive the smoke in the enemy's faces, by which the approaching fleet's movements are masked, Mr. Campbell says:

> As far as my experience teaches me, I have always found it as hard or harder to see through smoke driving before you as it is to see through it coming towards you; and I believe the ships coming up against the wind would be the first to see what formation the others were in.

For a fact, at Alexandria the English suffered from obscuration of their target by smoke, and since they were to windward Mr. Campbell's idea would seem to be borne out.

Captain Noel says:

> As it will be impossible to understand complicated signals in action, the only signals made should be very simple, need hardly be more than compass signals, and may be termed "action signals."

If possible, a semaphore should be used, worked from some protected tower, in place of the Army Code signal flag.

Captain Rivet is of the opinion that after an engagement has once commenced only those signals should be used which would give an order for retreat, or which would be needed to arrange the fleet in such a manner as to consummate the ruin and rout of the enemy.

IV.

We will now consider the sphere of the several weapons of a ship in a fight between fleets. Most authorities are of the opinion that the fire of the artillery should be by broadsides, and concentrated either abeam or slightly forward of the beam. Short range, say 500 yards, will be the ordinary fighting distance of ships. Commander Noel, in his work on the "Gun, Ram, and Torpedo," summarizes the duty of the artillery in action in the following words:

> Speaking generally of the use of guns in a fleet action, I am much of Captain Colomb's opinion, viz, that they should be previously laid right abeam and horizontal and then fired at the instant of passing an enemy's ship. I would lay down six rules[8] for the use of guns in a general action :
>
> 1. Guns are on no account to be fired unless there is every probability of their taking effect.
> 2. The broadside guns will always be trained on some prearranged bearing, from abeam to 15° before the beam, so that the captain shall at all times, and without giving a second thought, be certain of the exact direction in which his guns are pointing.
> 3. Guns as a rule will be fired by broadsides.
> 4. A disabled ship, with rudder or engines broken down, will use her guns to the utmost of her power.
> 5. A ship pairing off with an enemy to 'single combat,' moving around on the same circle, or finding herself on the same course as the enemy, will use independent firing.
> 6. As far as possible the aim is to be directed at the weakest points of the enemy.

The armor-clads of every nation should be a study, so that their vital points and weaknesses may be known. Large diagrams showing these should be accessible to all officers and gun-captains. Captain Noel further remarks that a turret ship, with all-round fire, should, when in line-of-battle, have her arc of fire curtailed so as to be available only between abeam and 15° before it, the same as any other vessel.

Mr. Besson says :

> The ram is the hardest weapon to employ, but it is the most terrible. Ramming, so difficult in a duel between ships, becomes more practicable in an action between fleets, as during a *mêlée* vessels, from the fact of being befogged by smoke, or through some accident, may find themselves in unexpected positions either of advantage or disadvantage.

Commander Noel is of the opinion that ships of the line maneuvering as a fleet cannot alter course and turn in any direction with the sole intention of ramming an antagonist. Whenever *ramming* is resorted to, it should, in his opinion, be done in this wise : Should the enemy be off his guard, his vessels should be attacked by the rams on their beam. These should maneuver to strike the enemy's vessels amidships when on a course making an acute angle with that on which the enemy is steering, instead of a right angle. By thus turning slightly towards the enemy's course, the rams would come in contact with less although sufficient force, and would by ranging up into the enemy's course avoid the ram bows of the next astern, instead of running through the lines and exposing their broadsides to the ships coming up.

Captain Rivet says that all armor-clads must carry torpedo-boats of great speed, which can be lowered during an engagement, with steam up, and ready for immediate action. A rapid merchant steamer can be fitted to carry four large-size boats. She should accompany the fleet. Vessels must carry torpedo-boats to satisfy the following conditions:

1. She must be able to lower and hoist them with facility.
2. The torpedo-boats must be of the largest size possible, considering the size of the ship.
3. The torpedo-boats should have the highest speed attainable.
4. These torpedo-boats should be possessed of the best nautical qualities. Especially should they have excellent turning power.
5. The torpedo-boats, boilers, and engines should be noiseless, and their coals should be as smokeless as possible.
6. The torpedo-boats' armament should combine efficacy and handiness.
7. The torpedo-boats should be able to obtain their steam pressure very easily.

This steam pressure may either come by temporarily connecting the boiler of the torpedo-boat with the ship's boilers, or by having the boat fitted with a boiler especially constructed for rapid steam-making.

In the first part of this chapter we said that lowering torpedo-boats preparatory to an action presents more difficulties than appear at first sight, and we propose to discuss the subject further. Two fleets make out one another 10 miles apart. If we give each fleet a speed of 10 knots, they will be together in half an hour. Nine times in ten, when the mutual sighting takes place, neither will be in formation for attack. By the time they have gotten into this order, which will take fifteen minutes, say, they will have lessened the distance between them to about 5 miles. Now, if at this stage either fleet attempts to get the torpedo-boats into the water, the other fleet would have a great advantage if they bore down upon them at full speed and engaged them. This separating sea could be covered in twenty minutes, and it is doubtful if this length of time will suffice to organize their torpedo flotilla and straighten up the line for battle.

It would seem, then, that the principal dependence for carrying the torpedo boat must be upon those vessels specially fitted for the purpose. Too much distraction to the line-of-battle will take place, as a general thing, if they are carried for sea use by those vessels composing this force.

Torpedo-boats are of course most necessary and must be provided, but it will be remembered we are discussing actions on the open sea. We can see most easily the advantage of a torpedo flotilla steaming in groups among the ships of the line of battle, moving in and out among the enemy, the boats picking up their work as it comes to them. We are rather of the opinion, though, that instead of forming an advance line and entering the action before the field of operations is obscured by smoke, and when they can be the more easily driven off by machine-gun fire, their time for gathering the best fruits of the contest will be *later*, during the *mêlée.* Indeed, it would seem to be a maxim that victory will lie with that fleet whose torpedo flotilla is first in action *after* the first charge, the state of the sea permitting torpedo-boats to be used.

Admiral Penhoat says that in battle all fires will be started; therefore, there must be two speeds taken as necessary during an engagement:

1. The maximum maneuvering speed, which is about 3 knots slower than the maximum fighting speed.
2. The maximum fighting speed, which is, when the formation is intact, the fastest speed of the slowest ship, and when the formation is broken up the fastest speed of the individual ship.

Captain Rivet is of the opinion that no faster speed than 8 or 10 knots will be maintained during an action. He says:

> To exceed this would make the firing very wild, and ramming dangerous for the attacking vessel. The engine, though, should at all times be ready to go ahead at full speed.

V.

It is not probable that a fleet will charge more than twice without losing its formation. The commanding officer of a section of two should strive, for mutual safety, to keep up the fleet organization as long as possible, but if it *is* broken, the section should act as a unit independently of the fleet, keeping a lookout for signals from the commander-in-chief. Sections of two ships should keep together as long as possible, the junior being under the immediate control of the senior captain, whose vessel will be in the leader. There is one exception to this general rule; the junior when he encounters an enemy's ship in his path should immediately ram her.

Commander Noel says that the secret of success in an action lies in the re-forming of the fleet after the order of attack has been broken up. The chance of victory lies with that fleet which can re-form first. If, in the midst of an engagement, the Admiral considers it necessary to re-form the line of battle, he should signal his fleet to draw out of action and to form on *him*, either in the formation in which the attack was made or in some other as signaled.

In regard to the question of maintaining a regular reserve squadron, there are two absolutely different opinions; for instance, Captain Harris not only believes in a reserve, but says that the arrival of the reserve on either side will decide the battle in favor of the side to which the reserve belongs. His idea, further expressed, is that the reserve should be composed of those armor-clads which make less than twelve knots. Other tacticians believe that there should be no reserve, and that every fighting vessel should be in the line of battle to engage the enemy.

Probably the most advanced idea is that certain vessels of widely different qualities from the majority of vessels employed should not be associated with them in the line of battle. These may form what may be termed a reserve division. They may be used to re-enforce the head or rear of the line of battle, or they may be employed to prevent a flank attack.

During a fight the duty of the squadron of cruisers, if it is seen fit not to employ them in the line of battle, would be to keep well clear of the ships-of-the-line, and be ready to assist damaged ships, cut off torpedo-boats, and to harass the enemy's smaller vessels.

To attack a fleet at anchor use the ram ; each vessel choosing a ship of the enemy to attack. A fleet at anchor must depend for its defense on torpedoes and booms, together with its flotilla of torpedo-boats. A fleet surprised at anchor is a contingency of war hard to realize. A fleet, however, caught in this manner would undoubtedly be destroyed.

During an engagement, if the Admiral wishes to retreat, the line-of-battle, by a simultaneous movement or otherwise, as soon as possible should come into some retreat formation. Strong stern fire now becomes a necessity. The wake of each ship should be thickly strewn with torpedoes. Most Admirals will prefer to retreat in lines ahead; if this is the case, the best ships should be kept in the rear nearest the enemy, the lighter vessels towing the disabled ones.

Should a fleet be surprised by an enemy when it is in no formation, each ship's bow should be turned towards the enemy, and a charge made through the enemy's line. When the other side is reached, they should form in the chosen way for retreat and fight the now turned and attacking enemy, or, if the occasion presented itself, they should turn simultaneously and attack their pursuers.

Two fleets meeting at night, how will they fight? The two fleets will probably not discover one another until they have approached each other to within three miles. Each fleet will probably be cruising in an irregular group formation, or else in two lines ahead. The electric light cannot be used indiscriminately, as you may blind your friend and perhaps have him into you. Your torpedo-boats cannot be gotten into the water, and no elaborate formation can be attempted. We will consider each fleet to have been well exercised by her Admiral in night drill, and that they stand on an equality here. It is thought that the fleet which is formed in line ahead in two columns will have the advantage over the fleet formed in any other way. In this case the leaders of the lines alone should use their electric lights. The leader of the column nearest the enemy should charge the enemy's line, followed by all the ships of his column, maintaining their formation in line ahead. As soon as the last ship in this column has her new direction, the leader of the second column, followed by his command in the line ahead, should charge some other point of the enemy's line. Each column should strive during the action to preserve the formation, and should pass and repass through the enemy's line, using artillery alone with concentrated fire. Small arms and machine guns should be rapidly fired at the moment of passing and at no other time. The leaders of the columns must understand that they must turn the one and the same way in reversing their direction to charge the enemy again. All movements made should be successive. Although some tacticians, as is stated somewhere in this work, say that the ram is the weapon of the night, it is believed that the most modern thinkers are of the other opinion. From these last we gather that ramming should only be incidental to the attack, and then only when the formation gets opened out, as it will. Should the smoke grow so dense as to obscure the field of battle, each ship in each column should sound its fog distinguishing signal, slow to quick speed, and the column leader should draw his column out of action in the direction then steered, and when the smoke lifts should charge the enemy's line again, with his column always following.

VI.

Different tacticians have different ideas as to the probable conduct of battles on the open sea between fleets. Captain Colomb believes that an engagement will be opened by a charge on both sides, followed by ramming and a breaking up of the formation. He is partial to a formation for attack of great depth and narrow front; that is, a line ahead, or some modification of it, standing down on the enemy in a direction perpendicular to his line of battle. His idea being to concentrate by piling his ships on some point of the enemy's line.

We have before observed that Captain Colomb is not partial to the group. We will now consider the plan of action of an author who is.

Commander Noel would have the enemy attacked in this manner: (See Plate XXIII, Fig. 1.) Approaching in column of two divisions, the enemy's fleet exposing a narrow front, the object will be to make it pass outside your nearest line; that division exchanging broadsides and moving directly ahead, keeping all the enemy's ships enveloped in smoke, and doing all the damage it can with its guns. In the meantime (or directly the leading ships meet), the other division, having been previously instructed, will turn eight points towards the first division, and, in a line abreast in groups, will pass astern of the first division and will charge the enemy along its line.

Admiral Randolph, in discussing an engagement between two squadrons, assumes that the enemy's plan of attack will be a charge in simple line abreast. He assumes also that the enemy's line will contain eight ships. Before unfolding his scheme for his special method of forming, he says that the Admiral should draw up several plans of battle, and they should be rehearsed before any chance of meeting the enemy occurs, so that when signal is made on sighting the enemy, "Use plan A (or B, or C)," each captain will know what to do.

For fighting the enemy in the formation stated above, the author places his fleet of eight ships on two of his lines of bearing, *A* and *B* (see Plate XXIII, Fig. 2), the Admiral on the left of the first division, the second in command on the right of the second division. These two commanders are separated, and therefore the two divisions, so that the wings of the fleet outflank the wings of the enemy a distance, say, of 1,200 yards. The second in command drops back his division, say, 600 yards, so that the fleets are formed as shown in the figure. The Admiral puts himself opposite to the third ship of the enemy, counting from the wing nearest to him. The second in command opposite the third ship of the enemy from the wing nearest him. The author chooses eight knots as the best fighting speed.

The fleets steer for one another, the ships of the author's fleet carefully keeping their stations. The Admiral and second in command, acting as guides, steer for the vessels opposite to which they have formed. When the Admiral gets at the point *X*, he dips his signal and each ship circles simultaneously, and tries to ram the ship toward which he turns. If they miss ramming their opponents, then the first division steer over to assist the second, No. 4 going to assist No. and No. 3 to No. 7, &c.

About this time each captain must take care of himself, but it will be seen that each division can steer down separately and attack the rear of the enemy.

If the enemy, instead of being in line abreast, were also in an echelon formation, the port division should not drop astern so much from the beam line of the starboard division.

Suppose, now, the squadron find themselves in the presence of each other under different circumstances, either somewhat suddenly, or one of them, standing in for the land in the morning, observes the other coming out of the port they have been watching.

The outside squadron (*A*) are in two lines (see Plate XXIV, Fig. 1); the other (*B*) has also been enabled to form in two lines, but has not had room enough to form abreast. *A* may be supposed to have what room he wants, and forms line abreast on a line of bearing by divisions, one division dropped to the rear, as shown in the figure.

As *B* will not have time and room to form, he will probably elect to cut through *A* in the 1,200 yards interval. With *A* formed as he is, *B* will run the risk of being pretty well used up by *A's* rams and bow fire, although *B* can get in a good broadside fire on *A*. As *B* goes through, each division of *A* turns towards the two columns of *B*. *A* can strengthen his formation by stationing 4 and 8 nearer the scene of the *mêlée*, say on the outer quarter of the Admiral and of the second in command.

Admiral Penhoat gives the following advice concerning the different formations for fighting with rams in squadron:

> If we should elect to attack the enemy in line abreast, we should charge him as normally as possible at good speed, and as we approach him each ship should try and pick out its opposite in the enemy's formation. To do this, each ship may have to maneuver either to one side or the other. This change of direction would be dangerous to make at a less distance than six cables from the enemy.

The Admiral thinks in the majority of cases that ramming will not be undertaken at the outset, but only after the guns have inflicted sufficient damage to prevent an enemy's maneuvering to evade an attack with the ram. If, however, at the outset, ramming the enemy is engaged in, the enemy may probably evade the shock; each ship, then, will pass close aboard the other, and they will exchange broadsides at close quarters, which should be very destructive. After the fleet have charged through the enemy's line, they should turn through 16 points, with helms all the same way, and return to the attack. The same general directions apply to the attack when formed in double line abreast.

This author has the following to say about concentration, and gives an example of a ramming attack: In regard to concentration it will be of little or no use between equal forces, except in the case where the fleets are very large. A concentration may be either *total* or *partial.* If a fleet is arranged for a ramming encounter, and its number of rams is double the number possessed by the enemy, the formation for attack in two lines abreast of equal length is naturally indicated. This is a total concentration. If the number of rams of the two fleets are equal, this method will not do, and a partial concentration must be made on some weak point in the enemy's line. In a concentrated attack the first line should be composed of the heaviest armored vessels, the second line preferably of rams. The first line is to use its artillery only. Ramming attacks on the broadside of a vessel, the rammer describing a quarter of a circle, are based upon an appreciation of the speed, essentially variable, of the adversary. This maneuver presents only a very few chances of success, if we reflect that with a speed of ten knots a vessel passes over her length in fifteen seconds.

In lines abreast, the flanks should be protected by other vessels, not belonging to the formation, but which act as a re-enforcement.

According to Mr. de Penfentenyo, the following plan of battle is the best to follow out. The proper formation for attack is the simple line abreast. After the first charge, vessels ought always to immediately reverse their courses, all heaving over their helms in a preordered direction, and form groups without further signal. (See Plate XXV, Fig. 1.) The group-leaders should become commanders-in-chief of their groups, and should maneuver them independently.

Should charging through the enemy's line be the scheme of attack, as nine times out of ten it will be, it may be laid down as a rule, that after having passed through the enemy's formation, vessels should return to the charge. If the formation is a line or lines ahead, the leader returns to the attack followed in succession by his line. The rearmost vessel alone may try ramming tactics, the others *must not* except for self preservation.

A German tactician in answer to the question as to how the fleet should engage the enemy, says, that if it advances in a formation of line abreast, it can use its rams better, but that its artillery is of nearly no avail, as it could hardly be used lest the fleet should fire into one another. The author suggests that, with the Admiral leading, the fleet should advance in line ahead steering for the nearest ship of the enemy. When within two miles, change course four points with the enemy's front by a successive movement, and when on this line, swing together on a course heading for the enemy. This brings your fleet into a bow and quarter line. (See Plate XXIV, Fig. 2.)

Mr. Besson says:

> The enemy being signaled, the squadron should form in line ahead and then steer for the enemy at full speed. If the enemy is in line abreast, it should try and isolate one of his wings and destroy it.

Or, to discuss the subject further, let us suppose one squadron to be in line ahead and the enemy in line abreast as has just been stated. Our squadron we will call A, the enemy B. (See Plate XXV, Fig. 2.) The leading ship of the A squadron receives the fire from all the ships of the B squadron as he approaches. If he is not stopped dead, which is unlikely, he will pierce the B squadron between B_1 and B_4, giving the enemy both broadsides. All the A squadron follows in line, and it is easy to see that B_1 and B_4 receives it hot and heavy. If it is supposed that the two squadrons steam at the rate of 11 knots, and are composed of six ships each, A squadron will pass through *B's* line in two and a half minutes. Consequently, the wing ships of B will not have time probably to give A_6 the benefit of their fire. The advantage belongs to A squadron all through from an artillery point of view. This advantage is as great, if not greater, from the standpoint of the auto-mobile torpedo, since B_1 and B_4 alone can use theirs, and yet they will receive the whole outfit of the A squadron.

If divergent torpedoes are used by the B squadron, A_1 and perhaps A_2 will be sunk by B_4 and B_1. But if both squadrons use them, they are on an equal footing, and B_4 and B_1 will have the same chances against them as A_1 and A_2.

From the standpoint of the ram, all the vessels of A except A_6 are flanked by their next astern, whilst as regards B squadron, B_1 and B_4 are not as well protected by their neighbors B_2 and B_5, placed on either side of them. B_2 and B_5 can both be rammed by any vessel in A squadron, but they in return can only ram one, and the next astern, as A_4, A_5, or A_6 will certainly sink B_2 and B_5 if they attempt to ram A_2 or A_3. From every point of view, then, the advantage remains with the A squadron.

The wing ships of B squadron not being able to use either guns or torpedoes, will seek to enter the fight by falling in rear of B_4 and B_1, and the formation of *B* will then be in two columns formed on the center, one column on each side of the *A* squadron. (See Plate XXV, Fig. 3.)

Even then *A* squadron will have the advantage in gun-fire, since it can use both broadsides; still, since the leading ships of *A* catch it so hotly they may be so injured as to throw their line into confusion. The advantage, on the whole, if *B*'s wing ships act as indicated in this last category, will belong to the *B* squadron, and *A* should never suffer itself to be entrapped into any such position. It would follow then as a *maxim*, that since a squadron in line ahead can change direction more easily than a squadron in line abreast, it should never attack a squadron in this last formation in the center, but nearer one of the flanks, preferably the weather one. To make this movement, *A* squadron should, when at some short distance from the enemy, change course eight points (see Plate XXVI, Fig. 2) by a simultaneous movement, and when abreast one of *B*'s flanks form line ahead and change.

Suppose that each fleet were in line ahead. The two lines pass close to one another, concentrating their fire on the head vessel of the opposing force. Each leader will probably succumb, and be rendered *hors du combat*. The only precaution against this which can be taken is to lead in with the vessel furnished with the heaviest protection. Whether we admit that the damage done to the leaders will be grave or light, the two lines will finally find themselves abreast one another. Each fleet will turn to ram the other and will collide or go through. The formation after this turn will be a line abreast for each fleet. After a mutual penetration of the formations, the fleets will turn about and again charge. (See Plate XXIII, Fig. 3.)

It will be seen from the figure, that vessels charging past the enemy do not do so, at the instant of passing, on a line abreast, but on a bow-and-quarter-line. This being the case, it will be observed that the gun fire is unobstructed, and that therefore char ging and recharging in this formation is good tactics, since there is little or no likelihood of firing into your friends.

Two fleets are in line abreast and have charged, and each fleet has turned, all the vessels with their helms the same way. It is apparent that each fleet has gained a diameter on the flank of the other, and that the next charge will be with vessels in *échelon*. (See Plate XXVI, Fig. 1.) This figure, by following out two or more charges, would go to prove that the formation would soon disappear as the flanks would be thrown out of action.

We have now examined into most of the theories of engagements between fleets which have been set forth and discussed by various tacticians. All of them are more or less unsatisfactory, from the fact that the premises of the authors are more or less biased in favor of their methods, and the enemy's fleet is generally considered to do the most unlikely thing. There is, however, much to be gained by studying these systems, but until the modern fleet meets its match on the high seas, we will have to content ourselves by dealing with hypotheses.

CHAPTER X.

OTHER DUTIES OF THE FLEET IN TIME OF WAR.

I.

In answer to the question "What is the chief object of war?" Admiral Aube discourses as follows:

> To inflict the greatest possible harm upon the enemy! We must expect then to see the iron-clad fleets, mistresses of the sea, turn their powers of attack and destruction, in default of adversaries, against all coast towns, fortified or not, pacific or warlike, burn, ruin, and at least raze them to the ground without mercy. This has been done at other times; it is done now; it will be done in future.

Captain Maubenge, of the Belgian artillery, in his paper on "The use of Artillery in Coast Defense," expresses the following opinion as to the motive in war, bearing out the views of the distinguished writer above quoted, but in language rather more mild:

> In war, the main object of ships is not to destroy the elements of defense, but rather to approach naval and military establishments so as to carry disorder and devastation into the ports, dock-yards, and arsenals, and to diminish the morale of the garrison and inhabitants. Often the fate of an invested place will be decided by the presence alone of one or two armored ships in its roadstead.
>
> Seamen can operate offensively in three ways:
>
> 1st. By remaining outside of the effective range of the coast guns and at a distance from the place equal to or less than the longest range of their own artillery. In such a position, by correct firing—which would be facilitated by the great size of the target—they would throw their projectiles into the place, whilst the defensive artillery, having a much smaller object to aim at, would have less chance of hitting it; and even successful shots, striking an armored vessel with a great angle of fall and with little remaining velocity, would produce very small results.
>
> In winding rivers, with high banks, floating batteries, or ships not heavily armored, will conceal themselves behind the banks, and only the smoke of their guns will indicate their position.
>
> 2d. The second method consists in forcing a passage without engaging the guns on shore. This plan will certainly be adopted by seamen, if the means of defense appear insufficient or badly utilized, or if they have some chance of succeeding by strategy. It will be resorted to if, after having crossed the dangerous belt, the ships can bring their broadsides to bear on the place, especially so if they have to fear only the fire of 12_{cm} or 15_{cm} guns. The intelligent seaman will not fail to attempt a measure, the success of which would be attended with such great results. This method would be used sometimes even when the roadstead was commanded by guns of great caliber, if the river or channel above the place was navigable and was not protected by coast artillery. After having passed the enemy's defenses, the ships would ascend the river until beyond his effective range, stopping at a good distance for bombarding.
>
> 3d. In the third place, ships can engage coast artillery. It is the middle course; seamen will resort to it only when the first two are impracticable, or are too danger-

ous. They will, perhaps, be led to attempt it when they have discovered defects in the defense, and have confidence in the impenetrability of their ship's sides, or in the great superiority of their ordnance.

If navigable rivers give access to the seaport on all sides, the mission of the attacking seaman is easier. If he be exposed only to the fire of fixed batteries, he can, by constant change of position, avoid their shots while bombarding at a good range. Naval establishments thus exposed can only be defended effectively with the co-operation of a fleet of coast-guard ships, and of floating batteries.

II.

Admiral Aube in his essay says further:

> The depreciation of the power of artillery against a movable iron-clad target has been verified by experience. It senslbly lessens the risks which an iron-clad fleet runs, covered with smoke and defiling at high speed before the most powerfully armed coast batteries.

This remark is borne out by facts. The experience being still more derogatory to artillery for the reason that the ships in the case in point were nearly if not quite stationary. At the bombardment of Alexandria some of the guns in the forts, constructed to penetrate armor of a certain thickness, although fired with approved charges and proper projectiles, failed to more than dent the comparatively light sides of the attacking vessels.

Some tacticians, in fact most of them, set it down as a *maxim*, that in attacking fortifications, fleets should engage at close quarters and fight under way. If the environment prevents this, then the fleet should fight bows on if possible. This, however, was not the tactics pursued by the English in the bombardment of Alexandria. The result of their experience was that there existed no greater danger in being anchored, and that their artillery practice was much more accurate when the ships were stationary. It must be remembered, though, that the fleet was not opposed by its equal in the art of war. During our own late war both methods were tried, and both satisfied the requirements of the circumstances of the occasion.

There were certain tactical experiences undergone by the combatants at Alexandria concerning which Lieutenant-Commander C. F. Goodrich, United States Navy, has come to the following conclusions:

1. Although vessels engaging forts will never be able to fight on equal terms with them, still forts will offer but little resistance to vessels attempting to run by them.

2. Under all circumstances the fleet should keep away from forts whose guns are mounted high above the sea-level on account of the danger to be incurred from a plunging fire.

3. Any projection appearing above the crest of the parapet of a fort furnishes an excellent target for the attacking fleet. It is a means by which the position of the guns is readily indicated and located, and which advantage the ships should be quick to seize.

4. Recent high-powered guns are not adapted to bombarding earthworks. Ships for general service should have a composite battery.

5. Ships should engage forts at moderate distances. With close range and a stable platform great damage can be done by shrapnel and machine-gun fire.

6. In all bombardments the target for the fleet should be:

(*a.*) The guns of the enemy actually firing.

(*b.*) Any building believed to be a store-house or magazine.

7. An advantage possessed by a vessel with a heavy fore and aft fire lies in its ability to anchor head to sea and engage a fort either ahead or astern from a comparatively steady platform.

7. If the ships and forts are about equal as regards artillery, the ships had better anchor. If the forts are the heavier the fleet should fight under way.

Every fleet surprised at anchor is a fleet destroyed; the ram, which the assailant alone should avail himself of, then becomes an arm as safe to him as it is destructive to his victim.

Every fleet at anchor, if the access to the anchorage is possible, can be surprised by night, or even attacked by day, by a fleet of torpedo-boats.

With the present defenseless state of our coasts, it becomes of vital interest to know that the range of guns of 27^{cm} is 12,500 yards, and that of a 14^{cm} gun is 10,000 yards, with an elevation of 35°. It is, in fact, even greater with the enormous muzzle-speeds now obtained, so that these guns can bombard every town, every settlement occupying a large extent of ground, and which any ship thus armed can approach within these distances. These towns will not only be bombarded, but they will be burnt or laid under contribution without the assailants running any serious risks from the coast batteries, or other shore or submarine defenses. The attacking vessels can only be successfully opposed and their progress barred by a fleet designed for coastwise defense.

Admiral Penhoat says that an attack upon a harbor or position on the coast involves three distinct operations:

1. The penetration of the port, or getting into a commanding or dominating position.

2. The bombardment or landing.

3. The disembarkation of troops and the occupation of the position.

The speed of a fleet is now so great that it can appear off a harbor, without notice, with means for destroying a fleet at anchor not well defended. To defend these vessels the author believes in a fortified breakwater or mole with narrow entrances. He does not pin his faith on either mines or booms, as he believes such methods will prove as great obstructions to the defenders as to the assailants. Nets are only serviceable under circumstances which are not likely to occur. A net caught in the screw would be worse than a shot lodging there.

III.

The blockade of the whole coast of a country possessing a navy is impossible; even that of a single port is difficult. Under any circumstances it can only be rendered effective by the concentration of numerous squadrons écheloned, as it were, on several concentric circles whose center is the port to be blockaded.

It is not likely, in the opinion of Captain Harris, R. N., that armor-clads will be employed as blockaders, especially at night, in the vicinity of ports known to contain torpedo vessels. Blockade should be maintained by light and swifter vessels, which, being cognizant of the positions of the armor-clads, will repeatedly communicate with them. In some blockades an opportunity may be afforded the blockaders to establish themselves in an adjacent harbor, and to use it as a base for their operations.

A vessel occupying the position of a blockader will be exposed to an attack from:

1. Auto-mobile torpedoes from a gunboat or torpedo-boat.
2. A spar or divergent torpedo from a cruiser, gunboat, or torpedo-boat.

Gunboats and torpedo-boats of the most recent pattern are able to use their torpedoes right ahead without stopping or changing course; therefore, if a blockading vessel is exposed to an attack from vessels furnished in this way with these weapons she can defend herself by—

1. Running away.
2. Sinking the attacking vessel before she has time to use her torpedo.
3. Fighting the approaching vessel with guns and her own torpedo-launches.
4. Using nets, booms, &c.

The first method is hardly to be thought of. If it was used, the enemy could keep the fleet constantly driven off.

The second method is more practicable. The attacking vessel must, however, be destroyed before she can approach within 600 yards. A heavy fire of manageable guns should be kept upon her. The only drawback is, that if the guns do not sink her, they will give her the chance she wishes to have, that is, an abundance of smoke to work in.

The third method is not to be entirely depended upon, because the enemy may glide between your launches; injured perhaps by your attack but not disabled.

The fourth method is hardly satisfactory, but when combined with the second and third, it seems all that is left to us. The moving torpedo-boat is a small object and moves rapidly, and consequently is hard to hit, but on the other hand it is easy to sink if your shot strikes it.

The above views are taken from a paper analyzed by a French writer from an English work on torpedo defenses. To-day the bulk of professional opinion is against the use of nets, &c., except in the case of anchored vessels which are disabled. In any technical sense, the best method is to use torpedo-launches combined with mechanical gun fire from both ship and boats. In time perhaps torpedo warfare will become very much modified through the improved construction of war vessels.

Armored vessels built for coast and harbor defense, but which can be taken to sea, may be of great use in an enemy's harbor where torpedoes are feared, to be pushed forward in the van in place of the more valuable armor clads of the fleet, since they have, as a general thing, great artillery power and good resisting qualities for their size.

Among the most useful elements of the besieging fleet is the telegraph-cable vessel. The cable-laying flotilla should consist of the tank vessel, containing the cable, small vessels to be used as receiving stations, and tugs for the heavy weighing and handling of buoys. The tank vessel should be capable of laying out and picking up the cable and should in every way be fitted for electrical work. The tugs will be used to run lines on shore. The cable should be a compromise between the shore-end and deep-sea cables, so as to stand well in shoal water and to permit of its being picked up and laid down many times.

Speaking of instruments and methods for signaling messages, outside of the electric telegraph, probably the best system, for day work, is with the heliograph, in any country with a good bright sun and a moderately clear sky. The advantage, where this instrument is used, is that the enemy is absolutely unaware of your action, unless he be absolutely located in the path of the reflected ray; that is, in a line between your two stations. During the night the heliograph is acceptably used with artificial light.

IV.

Should a fleet regularly besiege a port, the nature of the work to be done will, in a great degree, decide the class and number of tactical elements which will enter into it. Besides the fleet of line-of-battle ships, and the squadron of vessels composed of cruisers, corvettes, gun-vessels, tenders, and torpedo-vessels, there will be heavy wrecking tugs, surveying vessels to establish lights and buoys, a flotilla of smaller tugs and funimobile launches (or those steered and governed through a cable, by the system contrived by Lieut. T. C. McLean, Uniited States Navy), a submarine brigade for mining and countermining, telegraph vessels for laying cables, search vessels furnished with a powerful electric lighting installation, coal and ammunition vessels, commissariat and naval stores vessels, hospital ships, and floating repair shops. All these various elements, with their multitude of experts and attachés, must be protected by a convoy guard, the whole to be under command of a flag officer, who will need a powerful and efficient staff under him. He must have these vessels ready at all times to perform their individual functions and ready to get under way and make passages without going adrift. If the convoy is very large it should be divided into squads of not more than six vessels, and the convoy guard for each squad should be a section of two vessels at least.

In entering an enemy's inclosed waters it will be necessary to have a countermining flotilla precede the fleet where planted mines are suspected.

V.

A German tactical writer, as recently as this year, remarks that a shot entering a torpedo-boat will probably place it *hors du combat*, but a moving ship makes it very uncertain as regards striking such a small and fleet target even with mechanical gun fire. This author says that there is only one certain means for driving off the enemy's torpedo-boats, and that is to fight them with your own. The question then immediately arises, how does this class of vessels fight? Not with auto-mobile torpedoes, because the target is too small and too changeable for a torpedo; besides, the boats are not deep enough in the water. Two torpedo-boats could not ram one another without both being used up. The way will probably be, each boat will attempt to destroy the other by means of small gun-cotton spar torpedoes, by mechanical gun fire, or by the use of hand grenades. It should be the aim of a combatant to try and kill the crew of its adversary, as it is to be supposed that it is composed of skillful and daring men, and that their loss will be felt.

VI.

The following notes upon landing parties and the naval brigade are by Lieut. T. B. M. Mason, United States Navy, published in "Hamersley's Naval Encyclopedia":

> When everything is ready for leaving the ship, line ahead is formed, the steam-launch towing the column. A few oars in each boat are kept going, and if the wind is favorable, sails are set. In moving up a river care is to be taken not to be ambushed. Scouting parties may be landed if favorable eminences are near at hand, from which the banks may be viewed ahead. If attacked in a narrow river, in force, a fight should be made, and the advance continued after the enemy is repulsed. In a broad river, it may be safe to run by the enemy, if he is unprovided with boats. Care must be taken to destroy all boats which may be discovered on the way, as they might be used to cut off retreat. If it is found necessary to land to make coffee, one boat only should be detailed for the work, the others lying off ready for a surprise.
>
> Having arrived within shelling distance of the place to be attacked, a well-directed slow fire should be opened upon it. The boats furnished with guns should take up a commanding position; the lighter boats, after the landing or beach has been cleared, should move in and land their men, with the exception of those detailed as boat-keepers; the steam launch with a machine-gun moving in to cover the landing. If possible, the work of destruction should be carried out by this party.

In regard to a naval brigade:

> The circumstances under which a landing has to be made are so variable that no general rule can be laid down. The question, however, can best be discussed from two standpoints:
>
> 1. Landing on the water-front of a town.
> 2. Landing on a beach (the enemy opposing the landing in each case).
>
> On approaching the town, the covering vessels will take up such a position that they can shell the landing, and at the same time cover the land approaches to prevent the enemy receiving re-enforcements. The artillery boats will then advance and

take up positions to clear the landing and command the principal streets and buildings likely to shelter the enemy's riflemen.

The sea-face having been well shelled, the first line of infantry will pull in to the best landing-places. Once ashore, the first line of buildings will be occupied and manned on the land side. The second line now land, then the artillery, then the reserve.

On approaching a beach, the covering vessels must take up a position so as to enfilade any work that the enemy has erected, and to command the approaches. The artillery boats must clear the sand-hills and bushes back of them. The first line now land and advance as skirmishers, and, under the fire of the boats, must throw up light protections and occupy the line. Once established, they must open fire, and the second line will land with the artillery. The second line on shore, they will occupy the position of the first line, which will advance. The artillery will occupy any little knoll, cover itself, and open fire. The reserves, in the mean time, will have landed, and the whole body will advance. The reserves must intrench themselves, and keep the communication with the boats open. As soon as their guard is left by the advancing troops, the boats should be gotten ready for the re-embarkation of the party. In all cases the boats must be hauled off a little way and anchored with a hauling line on shore from the stern, the cable being long enough to veer in.

The boat guard should intrench themselves as soon as they land. In case of retreat, the first troops at the landing will relieve the boat guard, which will proceed to its boats.

In case of disaster, boat-keepers must be ready to sink such boats as are not needed by the fugitives.

Sometimes the shallowness of the water will not permit boats to land, or the only regular point of debarkation may be covered by the enemy's artillery, and the landing must be made elsewhere under circumstances which necessitate the use of a stage or float. Such a condition of affairs existed in the French operations before Sfax in Tunis, where the stage was made out of the topsail-yards of the line-of-battle ships, which were gotten into the water alongside, constructed into rafts, then towed separately near the shore, assembled together, and taken in under the direction of Captain Juge, whose report of this well-executed, delicate piece of work is as follows:

On Board the Marengo,
At Anchor off Sfax, July 18, 1881.

Admiral: I have the honor, in obedience to your orders, to report to you concerning the duty which was assigned me relative to the assembling of the floating bridge made in sections by the iron-clads of the squadron, and taking it ashore to assist in landing our men.

At 3 a. m. Saturday, July 16, the steam-launch of the Intrépide shoved off from the Marengo, towing the whale-boats placed at my disposition, each boat having an officer in charge. We steered for the gun-boats to whose care the different rafts had been confided the evening before. As soon as we arrived, the steam-launch took in tow the raft of the Marengo, which was to be the head of the bridge, and the others conducted by the whale-boats followed on behind, end to end. Under the supervision of the officers the lashings were promptly and securely made. The bridge being thus completed the whale-boats made fast along each side, and the steam-launch steering by the alignment of the two towers took us in to about 400 meters from the mole. At that distance I stopped and dropped a grapnel from the rear end, so that the steam-launch had only to tauten the tow-line to keep us on a line perpendicular to the beach; we thus offered the smallest target to the enemy, and at the same time we were in the best position to work rapidly. It was then 4.20 a. m., and we remained in that position during the bombardment.

> When the launches and native boats were almost abreast of us, by order of Captain de Marquessac, I sent the whale-boats to tow the native boats, keeping one man of each boat's crew for the oars of the bridge. The grapnel was weighed, the steam-launch went ahead, and the men pulled at the oars, trying to maintain the alignment of the bridge. We were soon obliged to cast off the tow, and we hauled ourselves in by means of a grapnel carried out by the Trident's dinghy, and a small anchor which I had sent ashore by the whale-boat of the Marengo. The boats which landed first interfered with our movements somewhat. We finally, however, made our bridge fast after the Trident's boat had landed, and our bridge served for the rest of the expeditionary force.
>
> I am, &c.,
>
> JUGE.

The naval brigade should be a fleet affair; every vessel should furnish a factor of the whole, but there should be no such organization as is now generally furnished by our ships of war, where all the elements are more or less those of a parade on shore, and are not such as the best offensive use of a body of men would call for.

VII.

Mr. Crompton has the following novelty to offer in the use of the electric light for the debarkation of an army at night. He says:

> It may be often necessary, on account of a dangerous coast, or signs of approaching bad weather, that this operation should be carried on at the utmost speed by night as by day. All the apparatus for producing the current would be retained aboard the steamships. The conducting cable need only be passed on shore. Tripod stands, to carry the lamps, would be placed at convenient intervals along the beach. The whole arrangement for lighting a mile of fore-shore could be got into position, and the lights shown in less than an hour's work by squads of men properly trained with the apparatus. The most difficult operations, such as landing guns and horses, will be carried on as easily by night as by day. If extreme celerity were needed, it is not absolutely necessary even to land the lights, the lanterns may be hung in such urgent cases from spars rigged out on the steam tenders or launches; the dynamo-machines being worked as before on board the ships. A distance between the machines and the lights may be as great as a mile without causing the cable to be unnecessarily heavy. I have not dwelt on the advantages which the light gives for night signaling, for they are sufficiently obvious.

The German authority, whom we have quoted a few pages back, is not in favor of the electric light being used on board ship for the general illumination of the situation, since he believes that its glare hinders, rather than helps, the vision, and by this means the torpedo-boat of the enemy obtains an excellent target.

To be used at its best, the electric lights of the vessels of the fleet should fulfill the following conditions:

1. They should be grouped at some one point, as, for instance, by installing a number of lanterns in some vessel or vessels, or on some point of land, connected by means of cables with a sufficient number of ships to afford a current, which ships shall, if possible, be masked from fire.
2. The beam from the concentrated light should fall on the object to be illuminated, so as to make as nearly as possible a horizontal right angle with the line of vision of the observer stationed elsewhere.

CHAPTER XI.

DEFENSE OF THE COAST AND TORPEDO FLOTILLA TACTICS.

I.

Since every point on the coast can become a place of debarkation f an enemy's army; every town on the coast can be burnt and pillaged by the hostile fleet, or even by simple cruisers, it is necessary to distribute over several centers of action the different constitutent naval elements for the defense of this coast. These comprise rams, floating batteries, corvettes, gun vessels of different sizes, and the various classes of torpedo steamers.

These, in connection with shore defenses, must guard and protect those points from which our squadrons and cruisers can escape into the open sea, and to which they may retreat for asylum in case the enemy be too formidable.

These centers must be beyond the range of guns of greatest caliber, and should prevent, by their number and their distance inland, the enemy knowing what is going on.

The defense of a coast comes within two categories, a stationary defense and a movable defense. The first comprises submarine mines, booms, fortifications of every kind, placed beforehand or extemporized on the coast; the second relies on the action, isolated or combined, of rams, floating batteries, gunboats, torpedo-vessels, &c., supported, according to circumstances, by armored ships, or even the sea-going squadrons, should circumstances so conspire as to render necessary this combination for war remaining in its own waters.

Admiral Penhoat says that the best coast defense is a fleet of specially constructed armor-clads, capable of going to sea in any weather along a coast. Then each harbor should have its flotilla of torpedo-boats. These coast-defense vessels should have great battery power, draw little water, have good speed, and be nearly unsinkable. They will require but a small amount of provisions, rather small crews, little coal on board, and large amounts of ammunition. They should be accompanied by lookout vessels.

These opinions of the Admiral are also formulated in the marine policy of his Government, so that it, in common with many other European nations, has organized fleets to fulfill this purpose. This system of defense should especially appeal to a country which is self-supporting, has no food routes to keep open, is concrete, and which has a large extent of coast line requiring protection, such as is our own.

Captain Harris says that gun-vessels and gunboats, small steamers, and tenders, are especially useful for coastwise employment. They should be under the protection of larger vessels, and should not be trusted far from their bases. They, and the coastwise armored fleet, and the torpedo flotillas should do their utmost to annoy a menacing fleet, and prevent its anchoring and blockading any port. They must be careful, however, not to bring about a general engagement, or to be caught at sea and cut off. Non-seagoing armor-clads are, as a general thing, of more value than fixed forts for the protection of harbors.

Coast batteries cannot alone prevent an armored squadron from forcing a passage; they must supplement their guns by mines. Conversely, any mine which is not protected by a gun is harmless, as it can be raised or destroyed.

Captain Maubenge expresses the following opinion in regard to torpedoes:

> It would be hazardous to place too much confidence in torpedoes, notwithstanding the perfection they have recently attained, for seamen will often succeed in raising them, in cutting their wires, in exploding them at a safe distance from their ships, or, still better, will build the latter to be almost, or quite, indestructible by torpedoes. This method of construction is that of water-tight compartments, whose partial destruction does not endanger the existence of the vessel.

II.

In regard to the question, which is the best to employ, a gun-vessel fitted with torpedoes, or a torpedo boat to use to make an attack with auto-mobile torpedoes, it is conceived that the gun-vessel has the following advantages:

1. It is harder to disable.
2. It can be used in heavier weather.
3. It is not obliged to stop to discharge its torpedoes.

As far as the torpedo-boat is concerned, Mr. Fontaineau lays down the following points in its favor:

1. Probably great speed.
2. Smaller target than a gun-vessel.
3. Great handiness, little momentum.
4. In case of accident fewer people lost.

Should practice prove to be true, the common report that torpedo boats will not have to stop to fire their auto-mobile torpedoes, the advantage will, however, lie strongly with this class of vessel.

If obstructions are placed about a ship, they must be strong enough to resist the onset of a vessel of fair size. A ship constrained to remain anchored must thoroughly mine her anchorage ground with a regular system of submarine defense. The cables for electrical connections can be stopped to the chain and come in through the hawse-holes.

To render the attack as irresistible as possible the torpedo-vessels must possess the following qualities:

1. Great speed, so as to enable the boat to be in the field of fire as short a time as possible, and so diminish the risk of being destroyed.
2. Show as little surface as possible, so as to reduce to a minimum the size of the target for the enemy's guns.
3. Be divided into as many water-tight compartments as possible to prevent being easily sunk.
4. Have the vital parts as well protected as possible.
5. A possibility of using auto-mobile torpedoes without reducing speed.
6. Protection for the crew against small-arm and machine-gun fire.
7. Noiseless engines, so as to put off discovery as long a time as possible, and so be enabled to approach the enemy.
8. Great handiness.
9. Armament with machine guns, to allow fighting a vessel of the same size interfering with its designs.
10. Facility of being handled out of the water and transported.
11. The most unobtrusive painting and disguise, to prevent being seen by the enemy's search lights.

The best torpedo-boats now possess most of these *desiderata*. There are some officers who pretend that this stopping to discharge a torpedo is no defect, for it lasts for only a minute, and the torpedo is ejected before the battery can be concentrated. Possibly this is so, still the fact that it *need not be done* certainly adds greatly to the tactical worth of the vessel.

In considering the defense of the vessel from an attack by torpedo-boats, the details of the fitting of the multitude of ingenious inventions devised to meet this end are not entered into by Mr. Fontaineau. In regard to the artillery, however, he says that it must fulfill the following conditions. Each gun must—

1. Be easily trained, permitting it to follow all the movements of the enemy.
2. Be capable of rapid loading, so as to fire the instant the aggressor comes in sight, and to keep it up.
3. Have the projectile heavy enough to injure seriously a gunboat or sink a torpedo-boat.

III.

Towing and spar torpedoes, owing to the improvement in machine guns, are now rarely fitted except as an alternative armament, as only under the most favorable conditions will it be possible to approach sufficiently near to a vessel to use them under the terrible hail of missiles which could be kept up by her machine guns. The result is that, at present, all the torpedo-boats under construction are armed with the automobile torpedo, and nearly, if not all, of them are armed with machine guns, to enable them to fight other boats, and to distract the guns' crews ship they are attacking.

The tactical qualities of the torpedo-boat must be as well known as are those of the ship. They must have their turning circles and helm-angles determined, and their commanding officers must be perfectly familiar with them. Their turning circles will be very large for their length, owing to their shoal draught of water and lightness. For this reason to insure quickness of evolution, drop-rudders have been invented and fitted.

That these points must be well known is patent from the fact that torpedo-boats must always attack in flotilla. The torpedo-boat acting singly has no place in modern warfare. No success can be derived from independent action, as the assailed vessel will always be more than a match for each individual boat.

Admiral Penhoat, in discussing this subject, says that the torpedo flotilla should be composed of boats representing two classes; one class capable of going outside the harbor, and the other intended to act in smoother water. The flotilla should be ready to attack at all times, being moored in ambuscades; natural features of a harbor being taken advantage of, if possible, to effect this object. They should be organized on a section or group basis, and they should be accompanied by swift tenders armed with a heavy mechanical battery.

A large number of tacticians believe that the best formation for torpedo-boats to resist an attack on a friendly ship by torpedo-boats is probably in double line abreast or in alternate lines abreast. The first line to charge the enemy's line and come around quickly, all boats turning the same way. The second line to keep between the attacking boats and the beset ship. The vessel should keep up a fire over the line of her own boats nearest to her. The ship should be underway and perhaps stopped; the line of boats nearest her would soon resemble a cordon, and the outer line should concentrate on the most dangerous point of the enemy's attack. The ship should retreat as soon as she sees her way out of the danger.

An attack on a vessel by torpedo-boats should be made with the flotilla divided into two or three divisions; one of these should act as a reserve. This last should either dash at the ship when the other divisions are engaging her torpedo-boats, or they should follow the ship when she seeks to retreat. If the ship must retreat through a channel, it would be a piece of strategy to have her attacked at one or two points in her passage out; the first attack being intended to engage her torpedo-boats, and not to destroy the ship.

Let us consider an attack on a fleet lying off and on the mouth of a harbor, by a flotilla of torpedo-boats at night. The boats should be divided into two or more divisions. Each division will tow astern of a corvette or tender. The slowest boat of each division will be nearest the towing vessel, and will, in the attack, act as the reserve boat. The towing corvettes and the reserve boats should be supplied with rockets and signal lights. The lines should tow out the harbor, each line separating as soon as possible from the others and towing each to some spot at about equally estimated distances from the fleet to be attacked. One or two heavy vessels should move out to the mouth of the harbor. When the corvettes and the heavy vessels have reached their assigned positions, they should drop an anchor under foot and stand by to slip. These positions should be so chosen by the Admiral that the torpedo flotilla shall be given every advantage of shelter and cover. At a certain set time, the torpedo flotilla will cast off from the towing vessels and be towed by the reserve boat directly towards the enemy. As soon as he is discovered each boat will separate from the reserve and dash for him. The painters connecting the boats had better be of chain, and each end should be slipped and the chain permitted to sink, otherwise the whole exploit might miscarry through a fouled screw.

No special rule can be given for attack, other than that the lines should mutually support one another. Each commanding officer of a torpedo-boat should be thoroughly informed of the appearance of each ship of the enemy, and the disposition of her vulnerable points. When the attack becomes general, the reserve boats should dash in. If the enemy is worsted the corvettes and heavy vessels should approach the scene and help the torpedo flotilla with their search-lights and weapons of offense.

If the torpedo-boats are obliged to retreat, they will fall back on the corvettes, and since these are separated, the boats will stand a good chance of picking up one of them, which will afford them shelter. Their chances, indeed, would be greater of their doing this than if the corvettes were all at one rendezvous. The anchorages of the corvettes should not be farther apart than a quarter of a mile.

An engagement between small vessels, bringing out several tactical situations, occurred in Callao Harbor during the Chili-Peruvian war, an account of which is as follows:

> At 2.30 a. m., May 25, a Peruvian old-type steam-launch, that formerly belonged to the ill-fated Independencia, commanded by Lieutenant Galvez, with a crew of sixteen men, and armed with a Gardner gun in the bow and a 2-inch breech-loading rifle in the stern, came suddenly upon the Chilian steel Thornycroft torpedo-launch Guacolda, which had a speed of 11 knots and was fitted with three spar-torpedoes, one right ahead and one on each bow. The Peruvian started at full speed for the mole as soon as he made out his enemy. The Janequeo, a steel Yarrow torpedo-launch, with a speed of 18 knots, now appeared on the scene, and passing ahead of her sister boat exploded her bow torpedo under the Peruvian's counter; at the same moment Lieutenant Galves and Surgeon Ugarte exploded a torpedo on the Janequeo's bow, which opened a large leak and killed two men. Her commander, Lieutenant Senoret, managed to get her alongside of a lighter, where she sank. Lieutenant Goni, in the Guacolda, continued to chase the Independencia, which kept up a heavy fire from her small-arms and stern gun. At last the Peruvians, finding their launch sinking, ceased firing and surrendered. Goni sent his dingey to her rescue and succeeded in saving Lieutenant Galves, seriously wounded, and seven of the crew. It was not till this

time that Goni missed his consort; but thinking that she had returned to the fleet, he went back to the flagship, put the wounded and prisoners on board, and finding that the Janequeo had not returned went in search of her. As he approached the floating dock he met Lieutenant Senoret and his crew coming out in two small boats which they had picked up alongside of the hulk Callao.

Besides doing their legitimate work, torpedo-vessels will have to fight small adversaries barring their passage. As we have before observed, they may be the enemy's torpedo-boats, but again they may be picket launches, tugs, or even booms and other obstructions. These will have to be overcome by machine-gun fire, hand grenades, spar torpedoes, and necklaces, or mines of gun-cotton or some other high explosive. For this purpose torpedo-boats should be fitted with the necessary weapons, leading wires, and batteries.

The attack on a fleet at anchor will rarely occur. However, *should* such a condition of affairs happen, the boats should separate, and, acting in pairs or groups of three, take as many vessels as possible at the same moment, and make as many victims as they can in the least time.

CHAPTER XII.

THE CONCLUSION.

I.

Sir Thomas Brassey, K. C. B., says:

> The loss of the Grosser Kurfürst occurred undoubtedly from the want of practice in fleet-sailing among the officers of the German Navy. On the last-named occasion the squadron of four ships was reduced to *one* in forty-eight hours after leaving Wilhelmshaven. On the first night one of the ships grounded on a sand-bank. On the following day the collision occurred between the König Wilhelm and the Grosser Kurfürst.

The destruction of a large vessel represents the direct loss of about $3,000,000. Then there are incidental losses of officers, men, and material of war. To these may be added the capture of a tactical center or the laying under bonds of a large business capital through the failure of this vessel to appear and defend it, making the amount of money involved, rise to such a sum that the imagination fails to follow.

With the certain knowledge that ships of such size are, and will be, needed; with the certain knowledge that just such ships, when we have them, will be lost through collision and bad handling, is it not the bounden duty of the nation to prepare for this condition of things, and in the interests of economy to see that its naval officers are well instructed in practical tactics and the handling of ships?

To again quote Sir Thomas Brassey, we read:

> The history of not only our own Navy, but that of all other navies which have attained any importance in the world, from the most ancient times downwards, has shown that tactical efficiency and naval success went hand in hand, and that the absence of the former assuredly led to the want of the latter.

This knowledge can never be gained in the class-room, since theory will not make a seaman, even in the case of men who have an intuitive faculty for seamanship.

Admiral Randolph, writing a few years ago, asks the question in regard to his own service:

> Are we taking every pains, not merely to perfect our few employed captains in their art, but to train and habituate all ranks of executives in the practical management of ships? We cannot think that an affirmative reply can be accepted as satisfactory until a system is established under which, at least, every second in command, and every lieutenant of a certain standing (who may of course at any moment become so, or even in charge of the ship), is made fully competent to do so by experience in handling one, not only in ordinary navigation, but in narrow waters, and all fleet evolutions.

> Why should there not be a systematic course of practical maneuvers, including experiments in turning under difficulties in the shortest time and smallest space; in stopping dead from different speeds, and going astern, &c., through which every executive should pass, in vessels of any available size, from steam pinnaces to big armored ships (the larger the better, of course, but nothing is too small to be of great value), to be carried out abroad and at home, whenever opportunities occurred? If economists are alarmed let them soothe themselves! * * * At the worst, it would amount to little more than the necessary coal, the saving of which cannot be justified and might easily turn out not only a pernicious but a disastrous economy. Let the financier who considers this a wicked waste of money put his price on these two qualities, viz, skill and nerve, but don't let him expect to get them for nothing; * * * they require careful and constant cultivation, and if desired of the best quality, must be paid for at the highest price, like all other commodities.

What is true of the British Navy is true of our own. If we have fewer ships, a more disheartening system governing promotion, and no punishment for mental laziness, our duty is still plain! Harder, more precise work, a devotion to a specialty, is what is required!

Since the necessity for a navy will arise, if it has not already arisen, it is but fair to conclude that one will be set afloat. It will be the practically instructed officer in the science under consideration who will proudly lead our new fleet into action and to victory.

If this work is demanded of the officer, what duty devolves upon the nation? Primarily, to establish a graded course for practical drill. Secondly, to maintain a squadron of evolutions.

It is not proposed here to draw up a course of instruction. Such a course will be the result of great thought, consultation, a utilization of the means at hand and available, and a gradual elaboration from time to time.

Every officer must be given a chance to serve in the squadron after passing through the school of practical tactics.

On this subject Captain Colomb says:

> I therefore feel the greatest possible anxiety that further steps should be taken towards the establishment of a systematic method of training our younger officers in the practical work of handling our ships at sea. The gunboat trials in the Russian squadron are full of information: a vast deal of information is got out of very little experience in that way, and it could be very easily carried out a little further than steam-launches and gunboats by larger vessels, which need not ram each other, but spars or rafts towed astern.

II.

Several years ago a squadron of instruction was organized in Russia. Several gunboats are fitted with fascines as buffers to prevent injury from ramming, and tournaments are repeatedly held in the presence of the superior officers of the fleet. Each gunboat is maneuvered by the captain of an armor-clad assisted by one of his officers and his chief engineer. In this way every captain, in his turn, has a practical lesson in ramming and being rammed or avoiding it, which they could not with safety attempt in their large commands. "All day long, and every day, one or other of the armor-clads, taking it in turn, is underway, threading her way backward and forward through the anchored fleet. The captain who makes the closest shave, without touching, is highly commended."

Naval tournaments should take place at sea between protected gunboats. These sea sham-fights would throw much light on disputed points in the rule of the road, and settle in a week what the most experienced and practical seamen may go on disputing about for years.

Much, too, can be learned in the way of fleet tactics from exercise in steam-launches. The launches should be organized as a fleet, and the movements, after determining the evolutionary circle of each launch, be gone through with. After the captains are thoroughly conversant with the drill, then astern of each launch should be towed a cutter. The helm-angle of the launch should be made smaller, and the launch and its tow should be considered as one vessel. Distances and intervals should be made greater to correspond with the new length, and the flotilla, under the new circumstances, should be again drilled in evolutions. By veering the boats farther astern of the launches, decreasing the helm-angles, and increasing the distances and intervals, the system of tactics resembles that of the movements of large vessels in its application.

By this means commanding officers can be brought to know fully the amount of room required in which they can maneuver their ships. Of course this method of drill is at best a makeshift, and that amount of nerve required in the commanding officer, nowadays, is in no way developed.

No course of instruction in tactics will be complete without a thorough discussion in some graphic manner of the relation existing between opposing ships and fleets. We think this end will be best served by a study of "The Duel: A Naval War Game, invented and arranged by Captain P. H. Colomb, R. N." Without entering into the rules governing it, it may be said that the game is based upon two ships carrying guns the same in number, but differently distributed, according to the choice of the players. The ships make the same or different speeds, according to lot. All during the combat, founded either on artillery or the ram, both ships must keep up their speeds; that is, they can neither slow, stop, nor back, and they must always use the same amount of helm in turning, so that each ship's turning-circle has an invariable diameter. There are different values for each gun when fired, and the battle is decided when one of the ships is rammed, kept under artillery fire, which she cannot adequately return, or when she is driven on shore or into neutral waters. We see here different speeds and varying helm-angles, for each ship is excluded from the game. The distinguished inventor, however, promises that they will be introduced as soon as sufficient authentic *data* is obtained bearing on these points. We can easily see that the sphere of this game, between experienced players, could be so enlarged as to include combats between fleets. Under all circumstances, whether played in its present simple state or whether elaborated into something very much greater, it should be found in the hands of every naval officer, who is interested in the highest and most conspicuous branch of his profession—the meeting and vanquishing of an enemy in a fair fight on the open sea.

Whilst this book is in preparation, the English are considering the necessity of following out the Russian system of drill. A class of gunboats is proposed, protected where necessary with buffers, going at a slow rate with low steam pressure, and using a small helm-angle. The idea is to make them unhandy in their movements, so as to resemble somewhat larger ships in their evolutions.

III.

The run across the Atlantic from New York to Queenstown is now made in a little more than six days. Nearly every week some new vessel distinguishes herself by her quick trip. Comparing the one which first made this great speed with the last one, we see a great gain in the expenditure of coal; so much less being burnt per ton of displacement, and larger runs being made on individual days.

In the near future we shall see an ordinary sea-speed of 20 knots maintained. If, now, this will be the speed of merchant steamers, there must be a cruiser class put afloat which will at least be their equals in speed, and their superiors in length of time in which they can keep the sea.

The tactician may well stand appalled at these immense speeds. What formations can be used for the ordinary purposes of navigation? In what order will the attack be made? What system of evolutions will be followed? And so on through the whole list of tactical requirements.

We fancy these questions can only be answered in a very general way. Any improvement in speed or turning power, or means of warfare, simplifies formations and evolutions, but enjoins greater complication upon the mutual duties of ships. It also causes a decrease in the number of ships which can with safety be set to act together. It may be that the number of vessels which can be combined will be only four, if, indeed, it is not two. Distances and intervals will perhaps be greater. The time during which a fire will be effective will last for only a few seconds. Then, again, the amount of sea traversed, after a charge, before a turn can be made, will be so great that a fight will only be possible on the open sea or in wide estuaries, between other than single ships.

The question now arises, since ships will be in a fight such a short time near together, what kind of guns will be used, and what will characterize the modern ship of war fitted for the line-of-battle? To us it looks as if the coming ship would be, as regards her hull, nearly, if not quite, torpedo-proof through numerous water-tight compartments coming up to the spar-deck; have her engines, boilers, and controlling officers protected; a large number of guns of moderate or even small caliber; labor-saving machinery everywhere, and therefore a small crew; no torpedoes; auxiliary rudder; and guns or tubes for firing some sort of high-powered explosive. She should also have a capacity for *full sail-power;* ordinarily to be barquetine rigged, with generous fore-and-aft "schooner" sails (lashed on the foot to booms, and not try-sails), with yards ready to go aloft and square sails to bend and set.

In conclusion, it may be mentioned that the foregoing pages have not been written with any idea of exciting controversy, but to refreshen the line of thought upon a subject which is at present engaging the minds of the officers of the navies of most foreign Governments. It may be, that enough has been drawn from the works of others to stimulate an endeavor to develop scientific research in a direction at once very interesting and vitally important.

◆

Plate I.

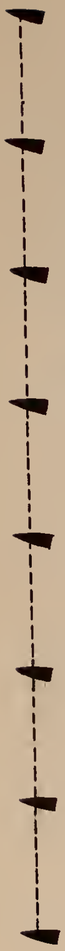


Fig. 5. Echelon. 1 point bearing. (Randolph's Modification.)

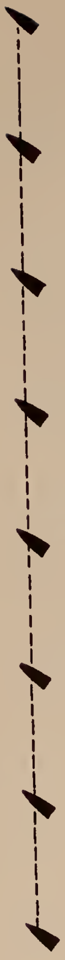


Fig. 4. Echelon. 3 point bearing.

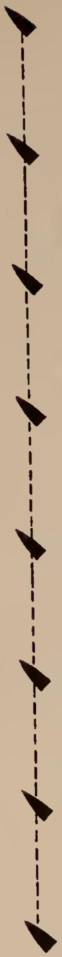


Fig. 3. Echelon. Bow and Quarter Line. 4 pts. bearing

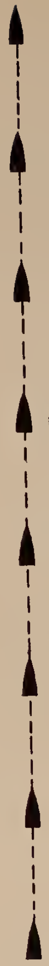


Fig. 1. Line Ahead.

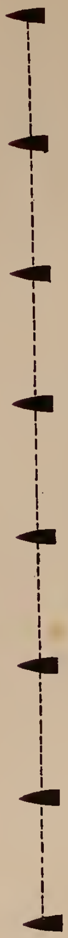


Fig. 2. Line Abreast.

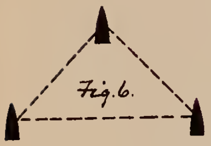


Fig. 6.

Group

Right Angle Triangle

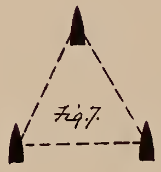


Fig. 7.

Group

Equilateral Triangle

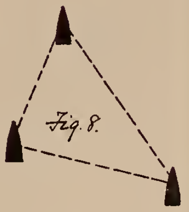


Fig. 8.

Group

Scalene Triangle

Plate. II.

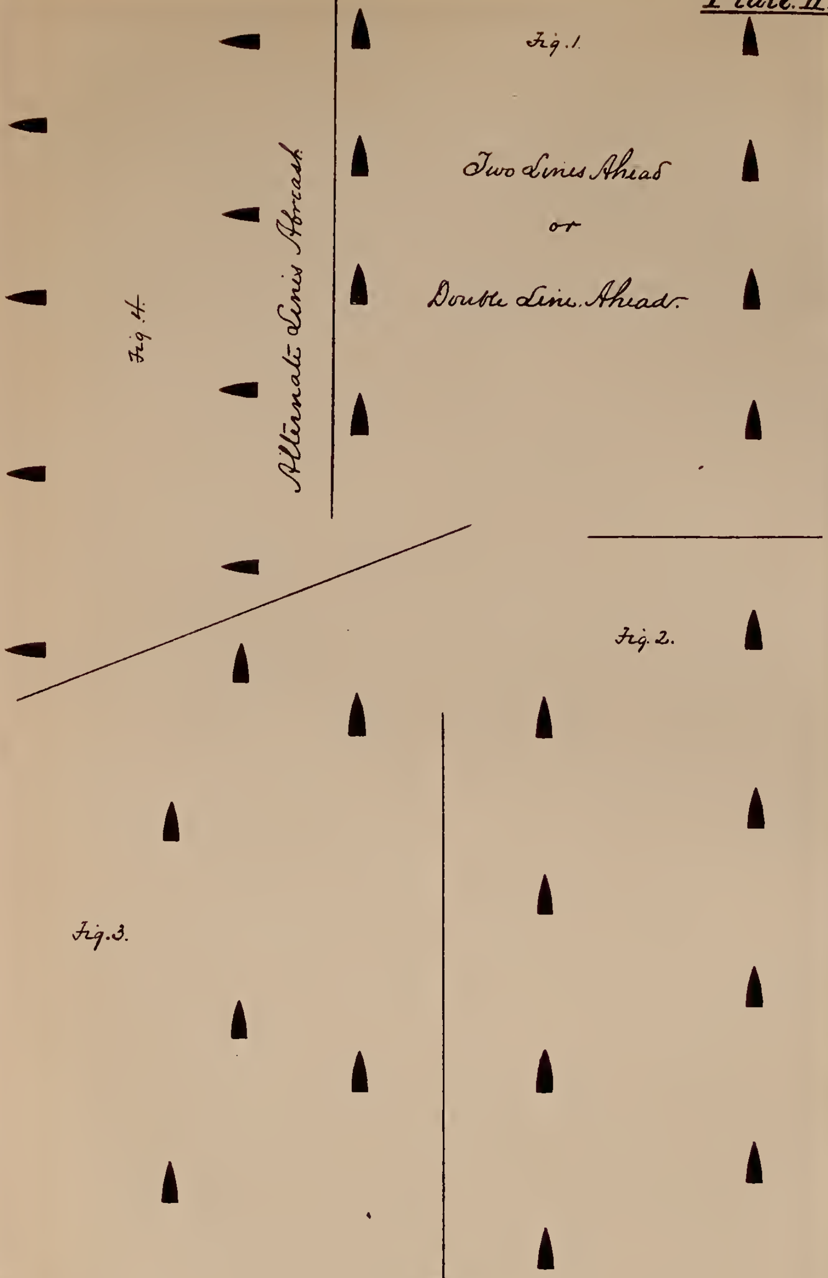


Fig. 1. Two Lines Ahead or Double Line Ahead.

Fig. 2. Alternate Lines Ahead.

Fig. 3. Line Ahead in Groups.

Fig. 4. Alternate Lines Abreast.

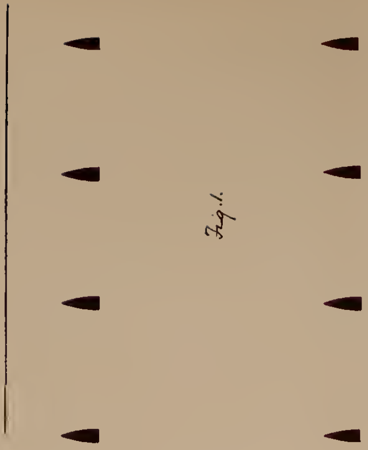


Fig. 1.

Two Lines abreast, or Double line abreast

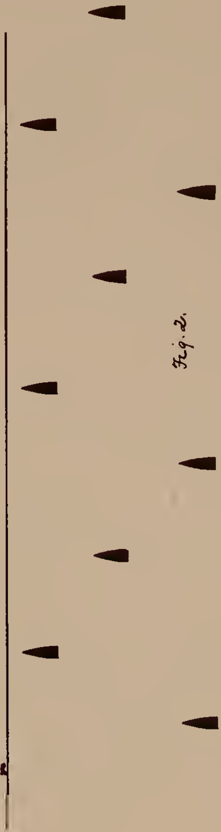


Fig. 2.

In Groups in line abreast.

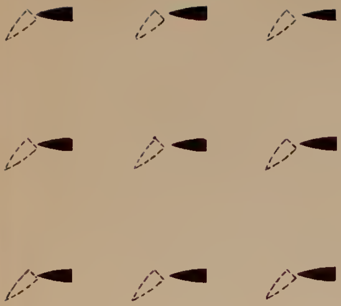


Fig. 3. Naval Square.

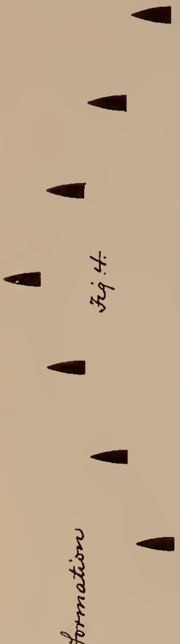


Fig. 4.

Chase formation

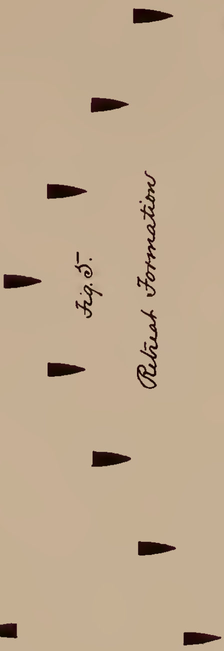


Fig. 5.

Retreat Formation

Plate IX.

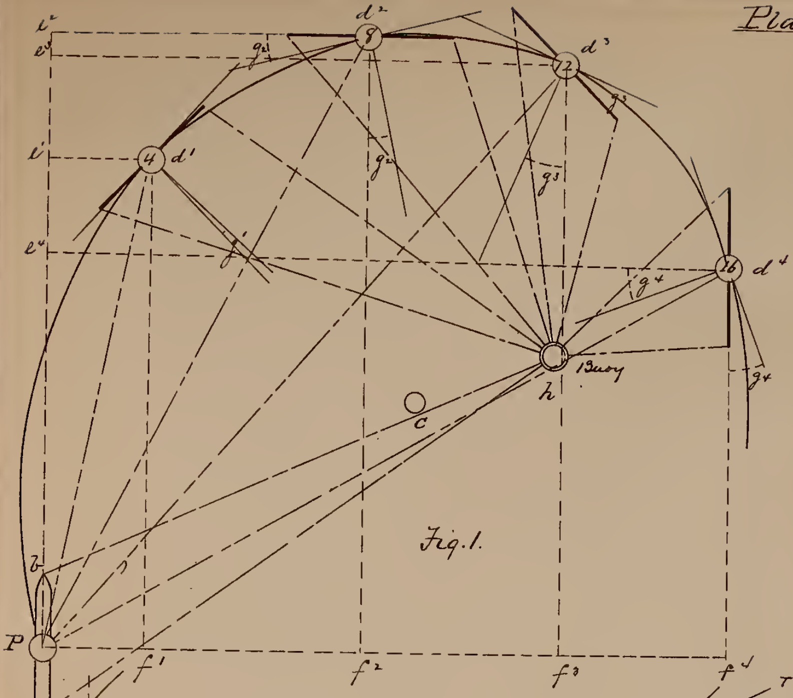


Fig. 1.

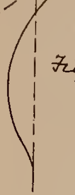


Fig. 2.

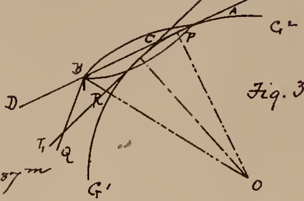
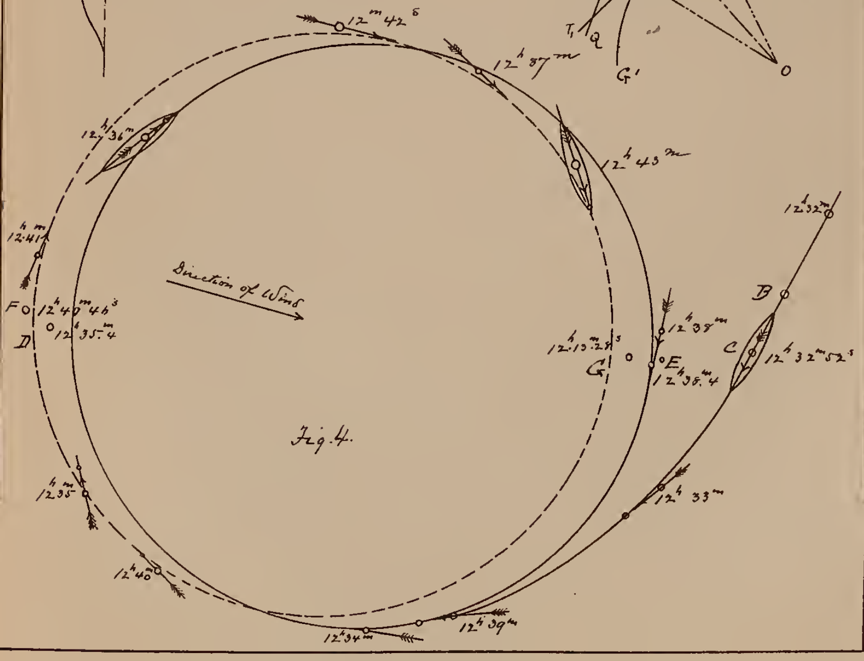


Fig. 3.



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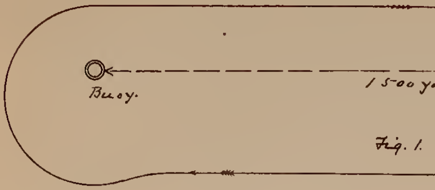
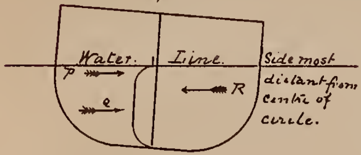


Fig. 1.

Fig. 2.



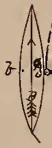
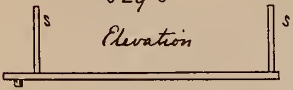
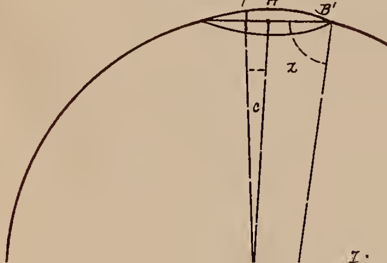


Fig 5
Elevation



Position 3.



Position 1.

Plate VI.

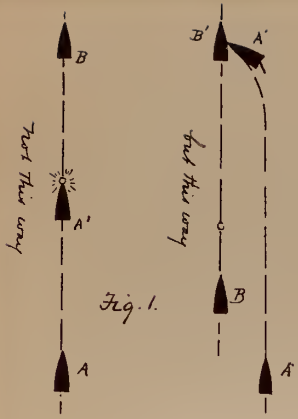


Fig. 1.

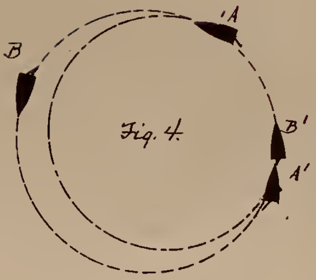
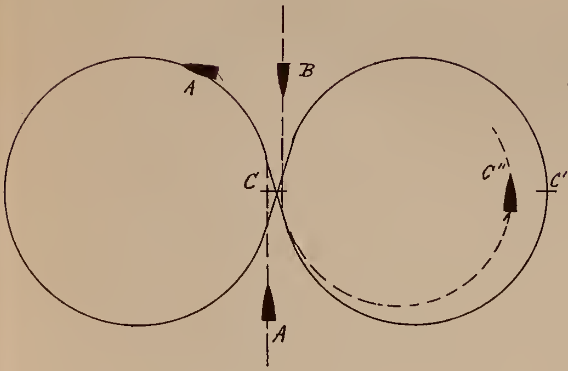
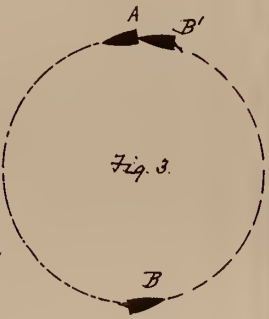


Fig. 4.

Fig. 2.





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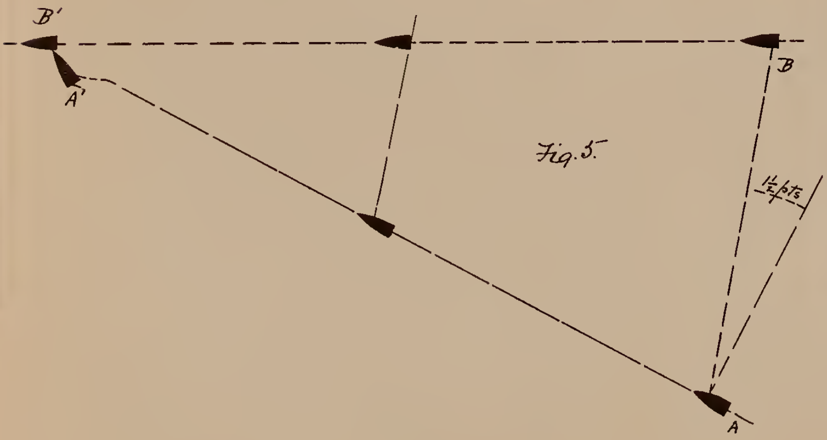
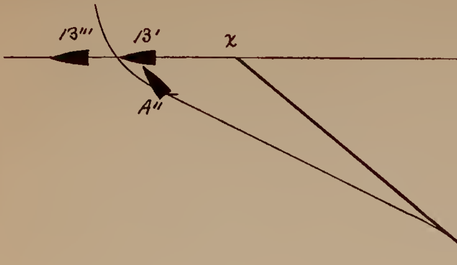


Fig. 5.



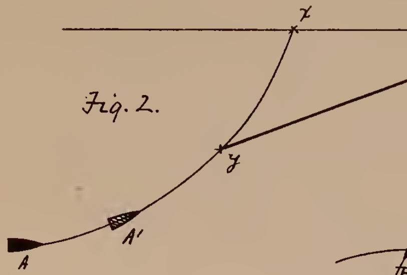
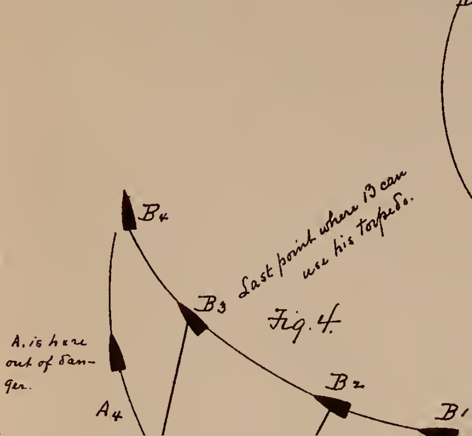


Fig. 2.

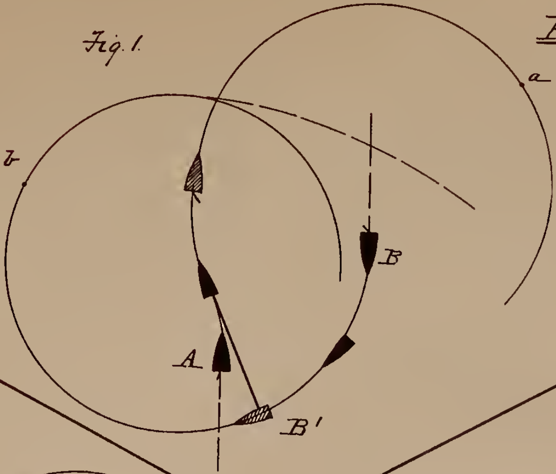


Last point where B can use his torpedo.

A. is here out of danger.

Fig. 4.

Plate. VIII.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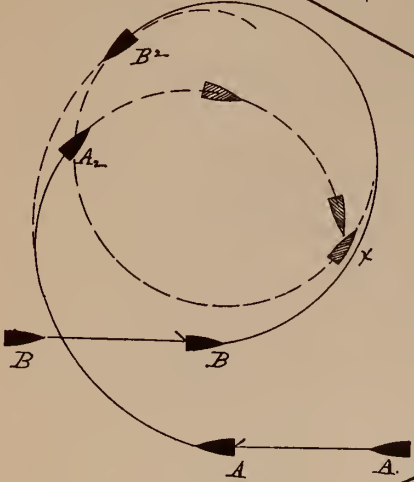
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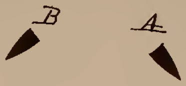


Fig. 3.

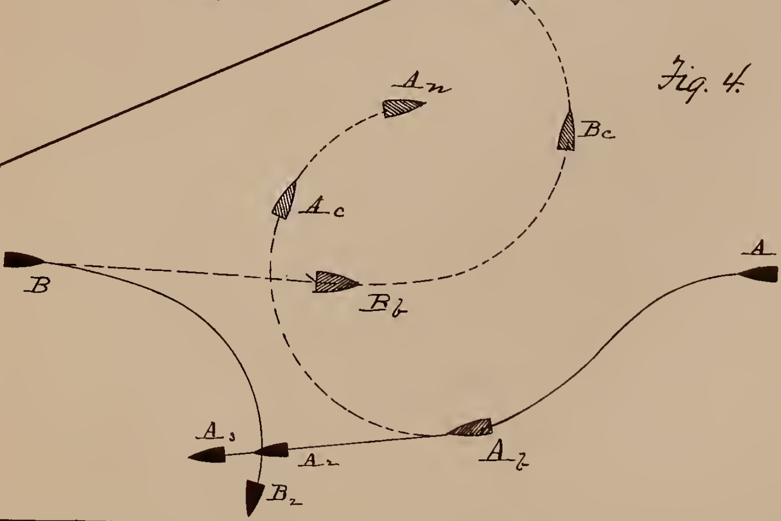


Fig. 4.

Plate IX.

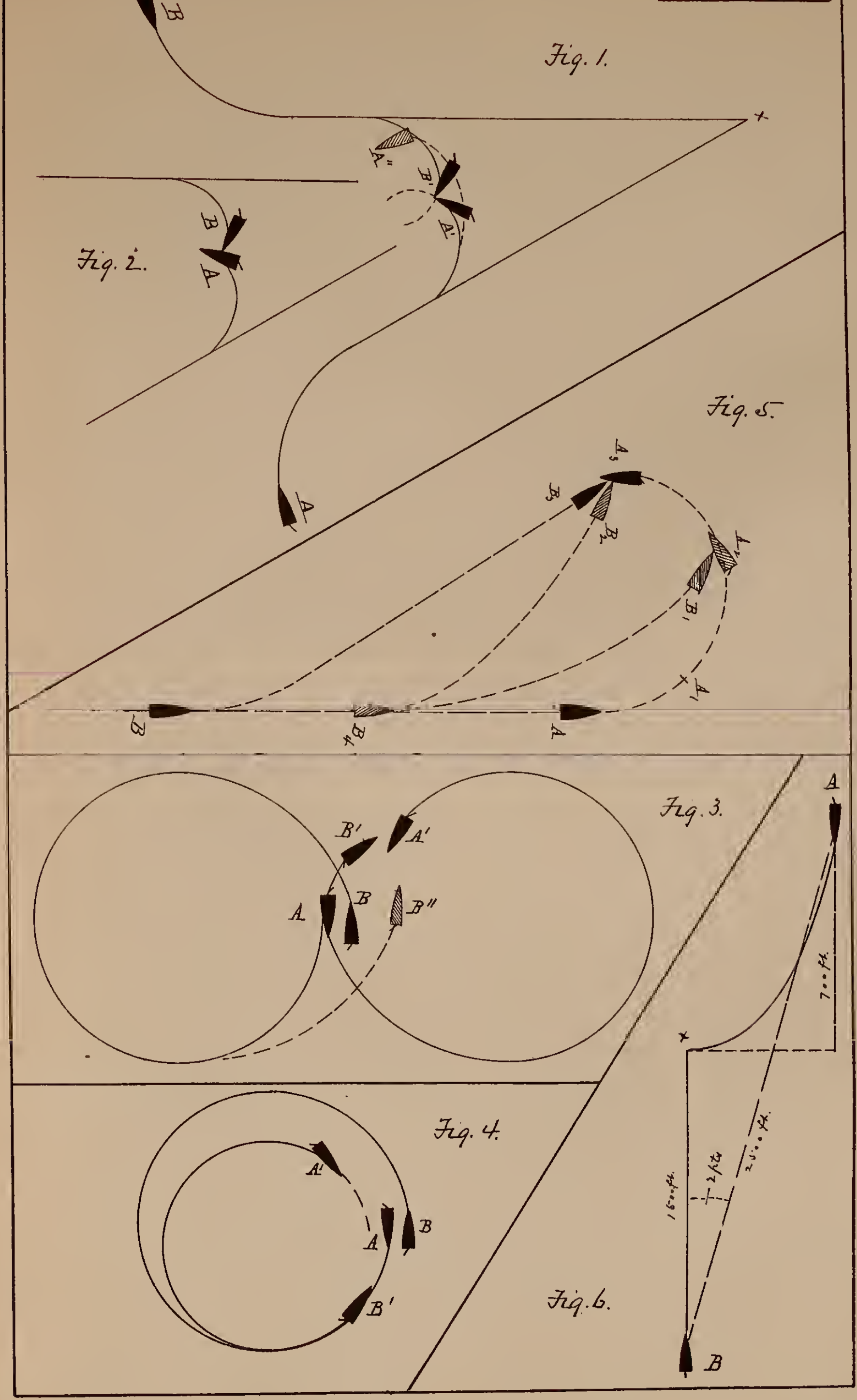


Fig. 1.
B
A''
B'
A'
A
Fig. 2.
B
A
Fig. 5.
A3
B3
B2
A2
B1
A1
B
B4
A
Fig. 3.
B'
A'
A
B
B''
A
Fig. 4.
A'
A
B
B'
Fig. 6.
700 ft.
1500 ft.
2 Kts
2500 ft.
B

Plate X.

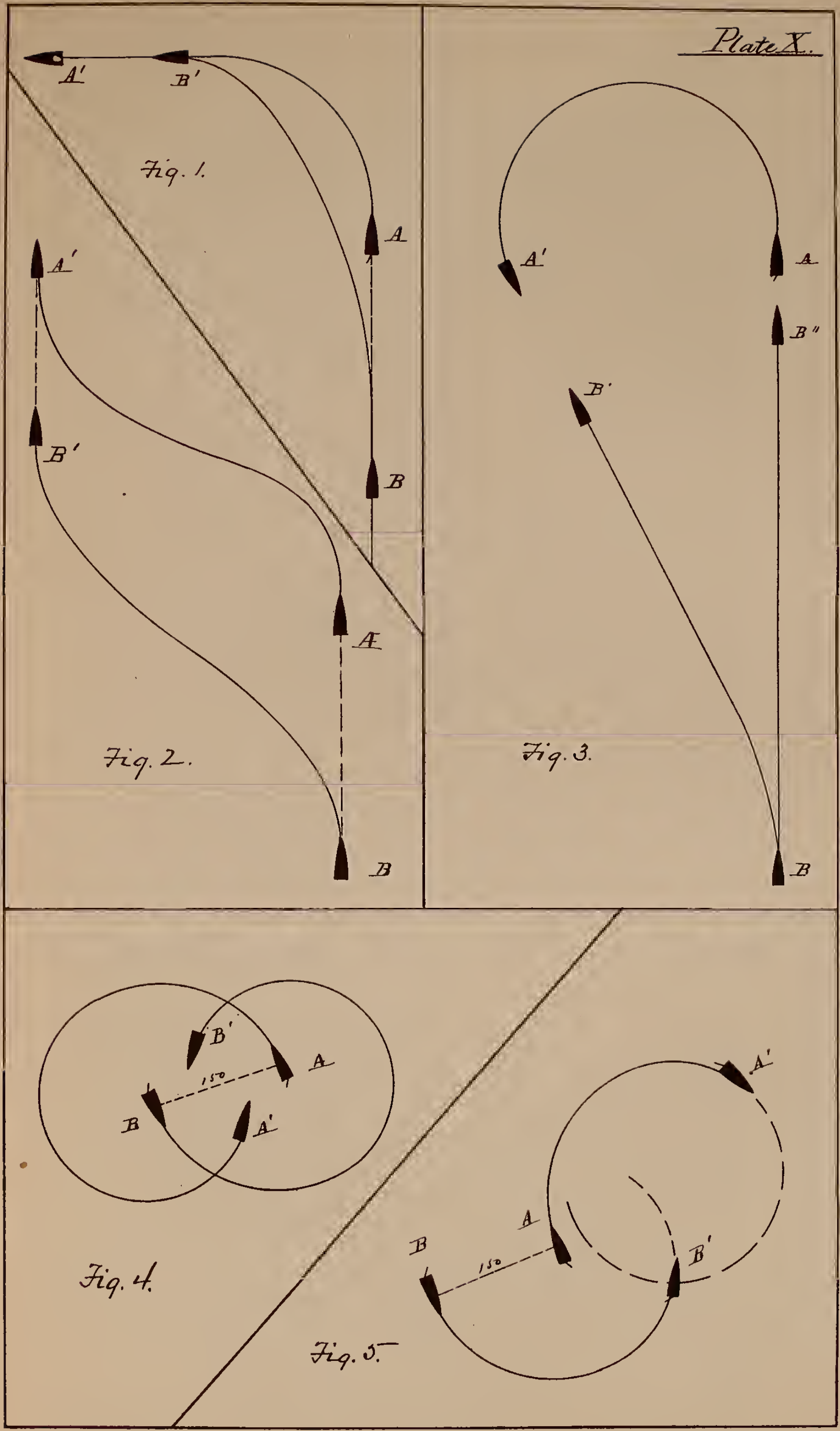


Plate XI.

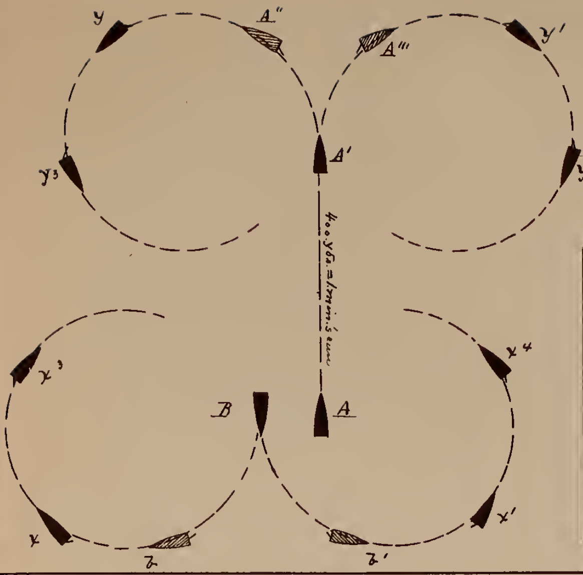


Fig. 1.

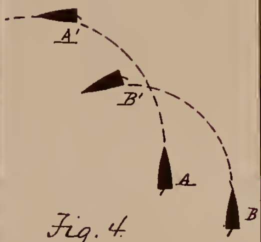
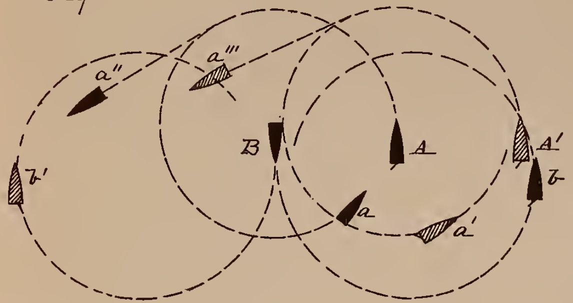


Fig. 4.

Fig. 2



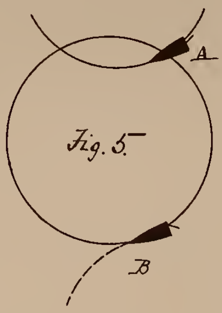


Fig. 5.

Fig. 3.

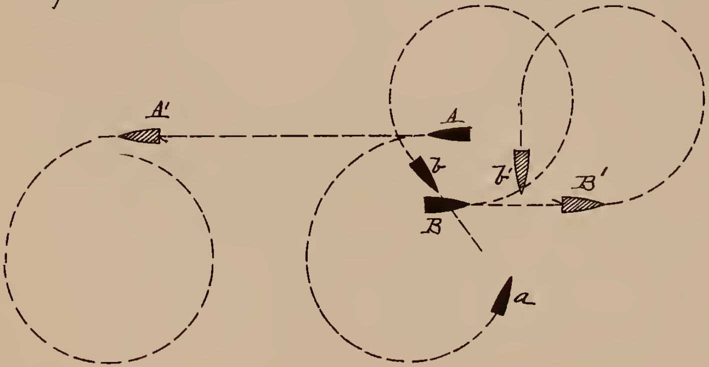


Plate. XII.

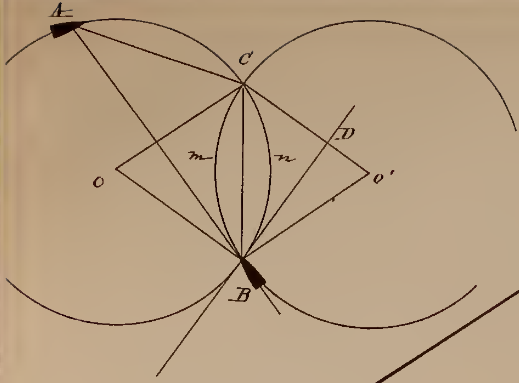
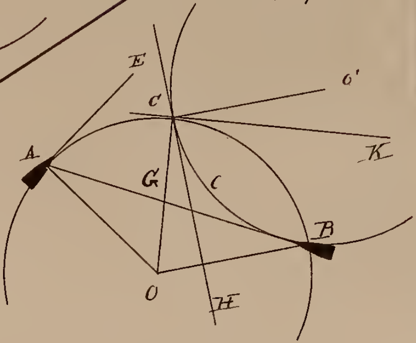


Fig. 1.

Fig. 2.



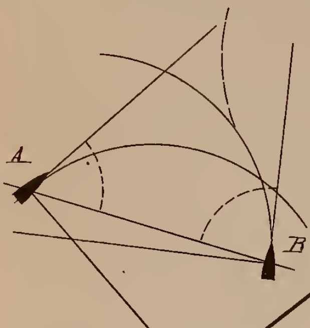
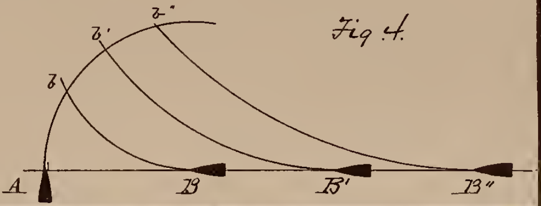


Fig. 3



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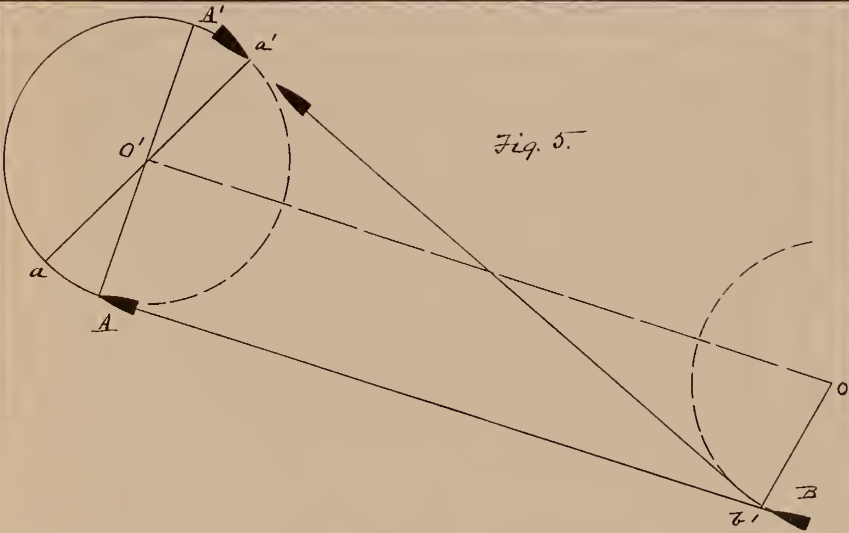


Fig. 5.

Plate XIII

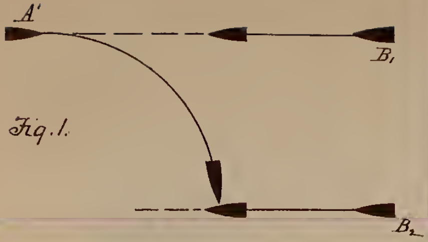


Fig. 1.

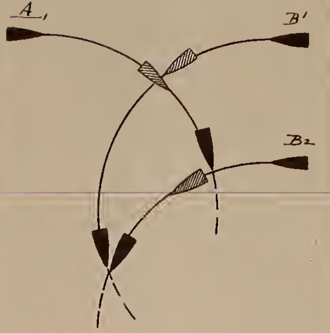
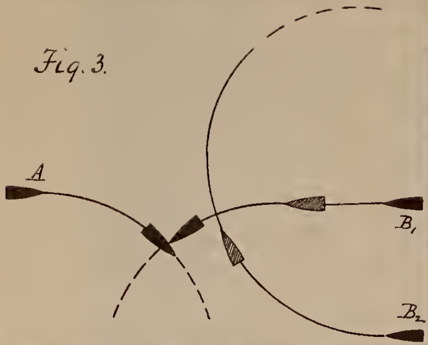


Fig. 2.



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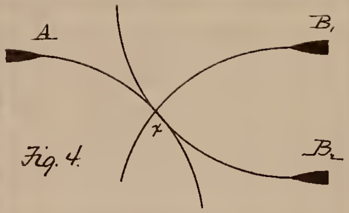

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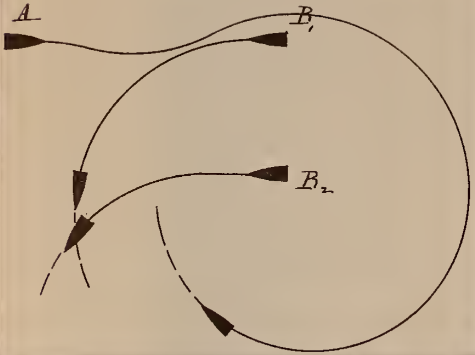

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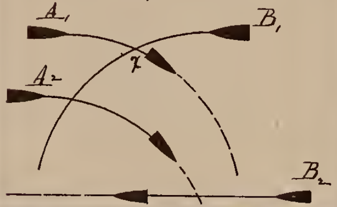

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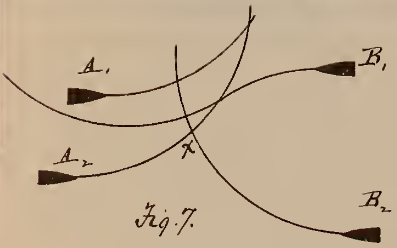

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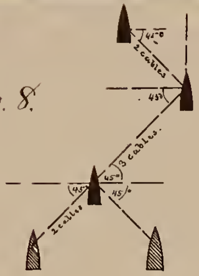


Fig. 8.

Plate XIV.

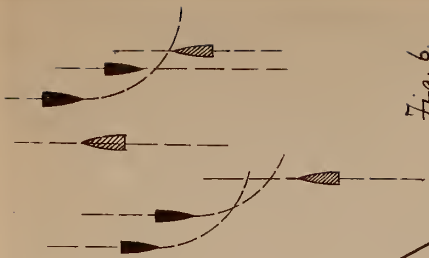


Fig. 6.

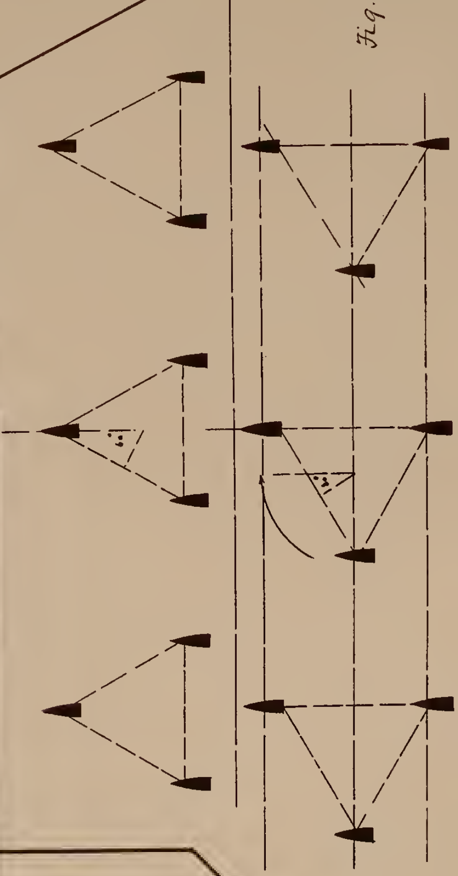


Fig. 5.

Equilateral Triangular Groups revolved through 30°

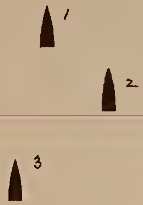


Fig. 1.

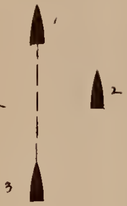


Fig. 2

No. 3 under cover

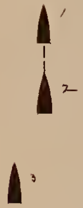


Fig. 3.

No. 2. under cover

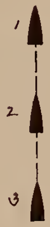
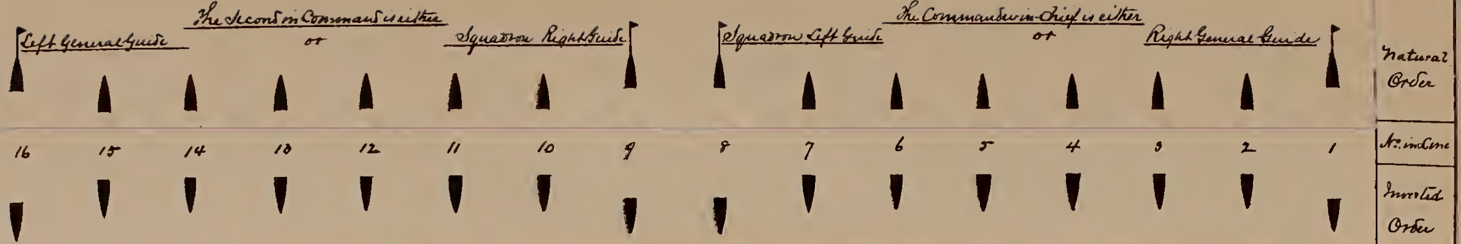


Fig. 4.



Leader	Mate	Mate	Leader	Leader	Mate	Mate	Leader	Leader	Mate	Mate	Leader	Leader	Mate	Mate	Leader	Organization Titles
Section H.		Section G.		Section F.		Section E.		Section D.		Section C.		Section B.		Section A.		
4th Division				3d Division				2d Division				1st Division				
Left Squadron								Right Squadron								
Fleet in Line Abreast.																

A System for assigning Distinguishing Numbers to the Ships of the Line of Battle

Basis of the Group of Four, or the Division. (16 ships)

44. 43. 42. 4. 34. 33. 32. 3. 24. 23. 22. 2. 14. 13. 12. 1.

Basis of the Group of Three. (9 or 12 ships)

43. 42. 4. 33. 32. 3. 23. 22. 2. 13. 12. 1.

Basis of the Section. (16 ships)

82. 8. 72. 7. 62. 6. 52. 5. 42 4. 32. 3. 22. 2. 12. 1.

Plate XV.

Plate XVI.

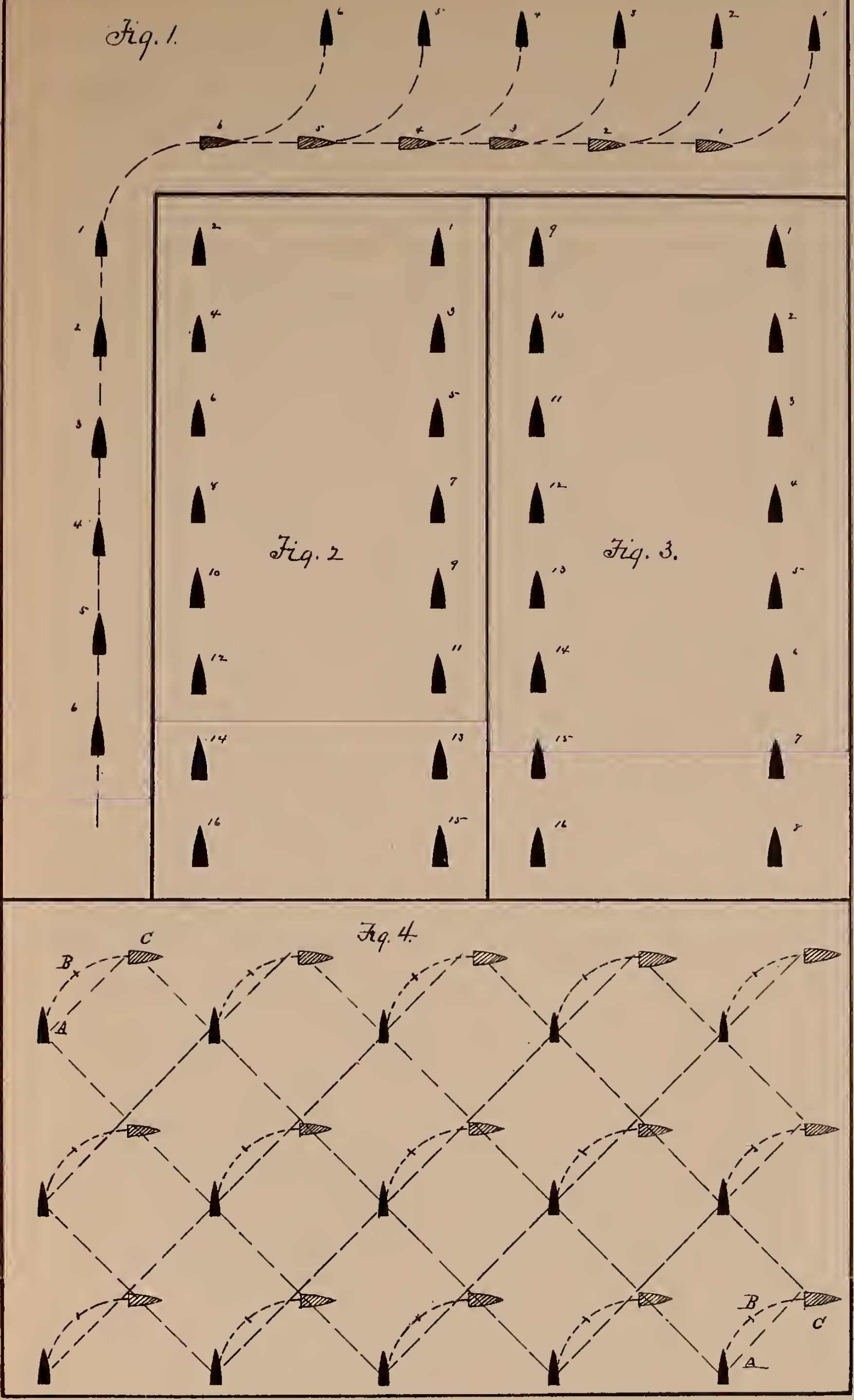
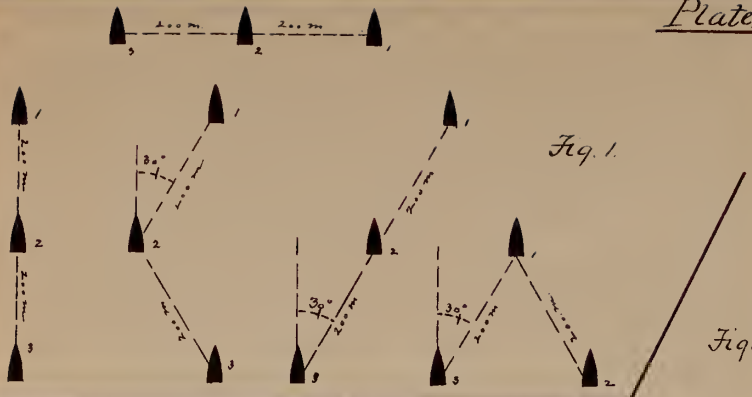


Fig. 1.
Fig. 2
Fig. 3.
Fig. 4.
C
B
A
B
C
A

Plate XVII.



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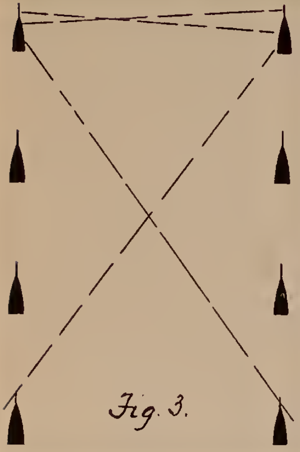


Fig. 3.

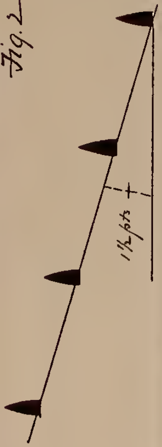


Fig. 2.

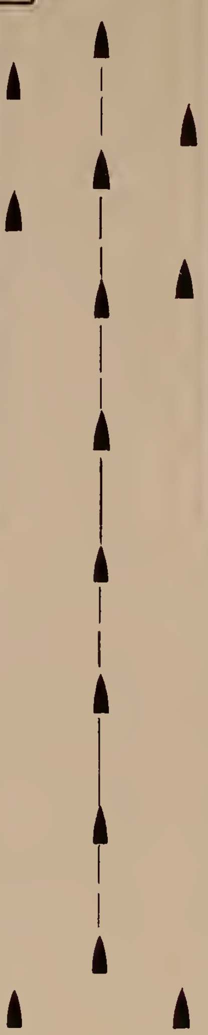
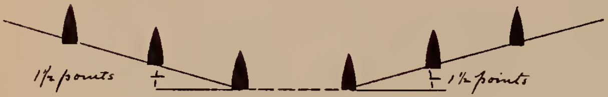


Fig. 4

Fig. 6.



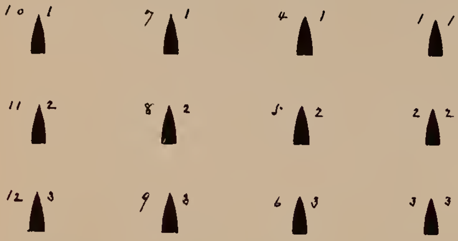


Fig. 5

Plate XVIII.

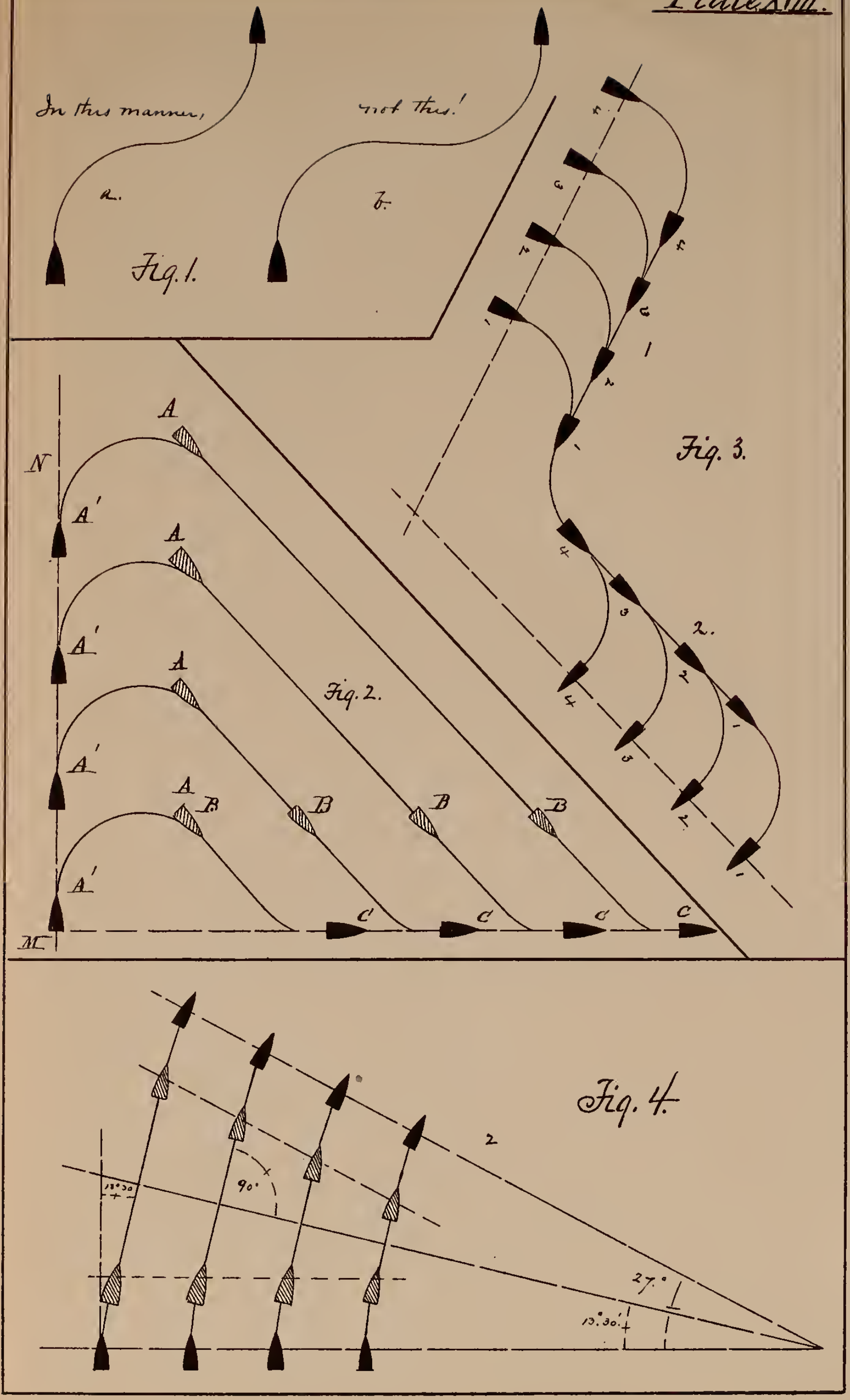
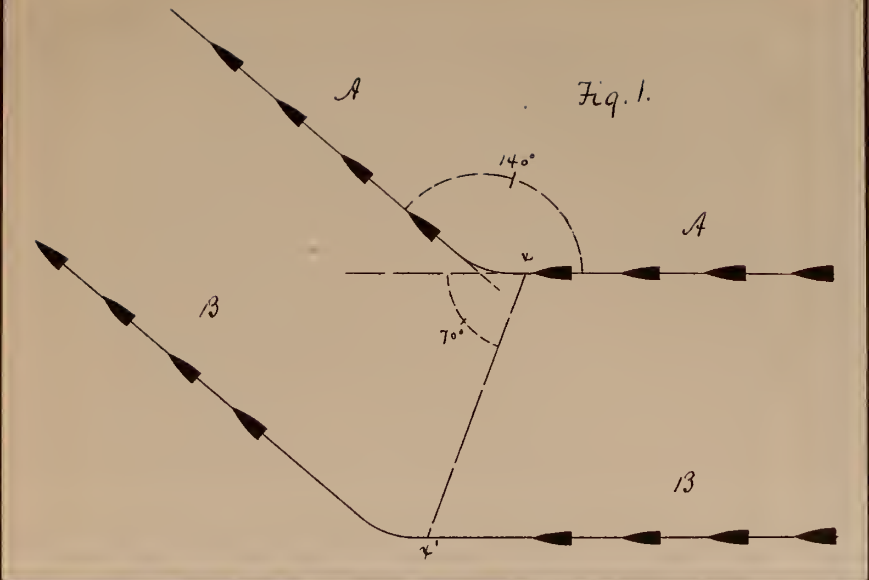
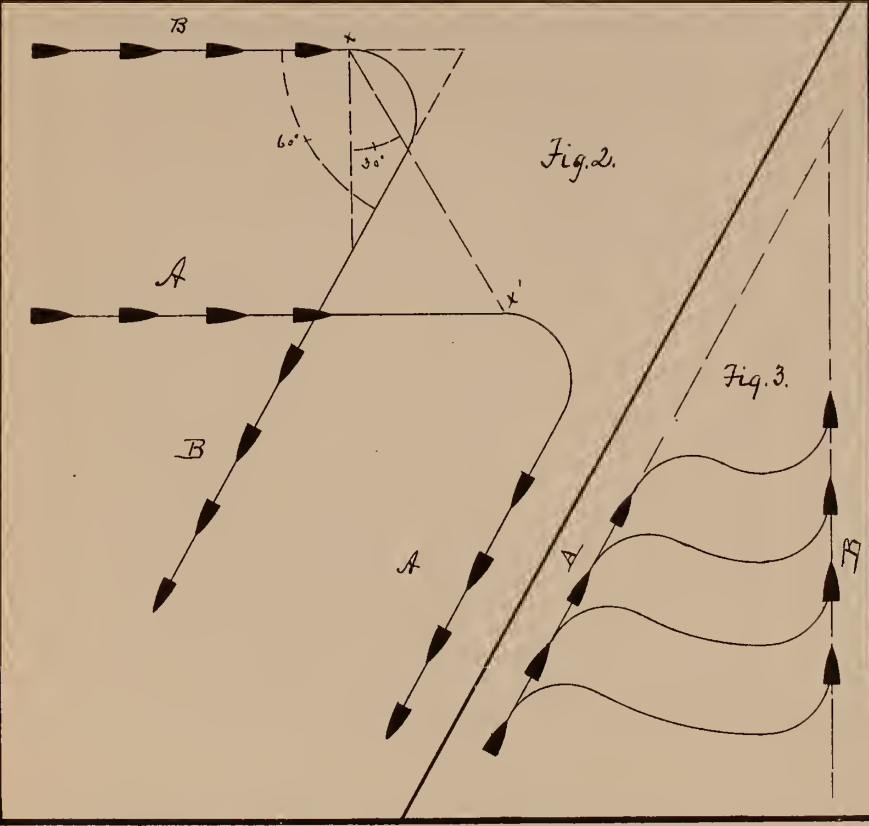

In this manner,
not this!
a.
b.
Fig. 1.
A
A'
N
M
B
C
Fig. 2.
Fig. 3.
1
2
3
4
2.
Fig. 4.
90°
13°30'
27°
2

Plate XIX.





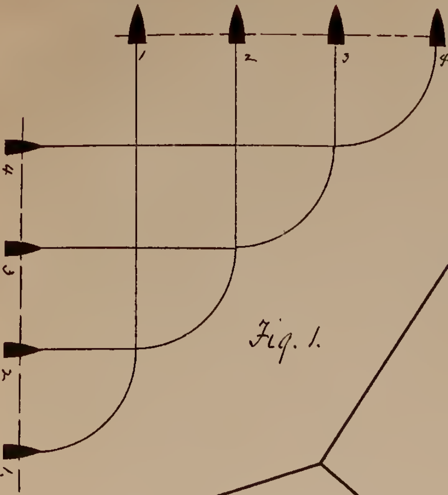


Fig. 1.

Fig. 3

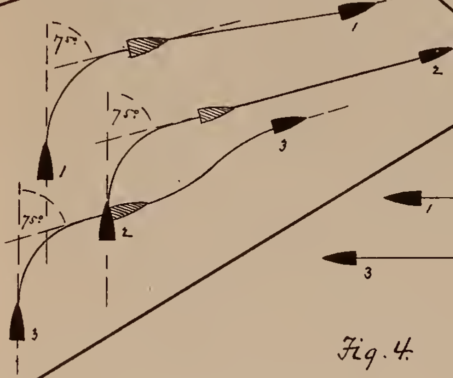


Fig. 4.

Plate XXI.

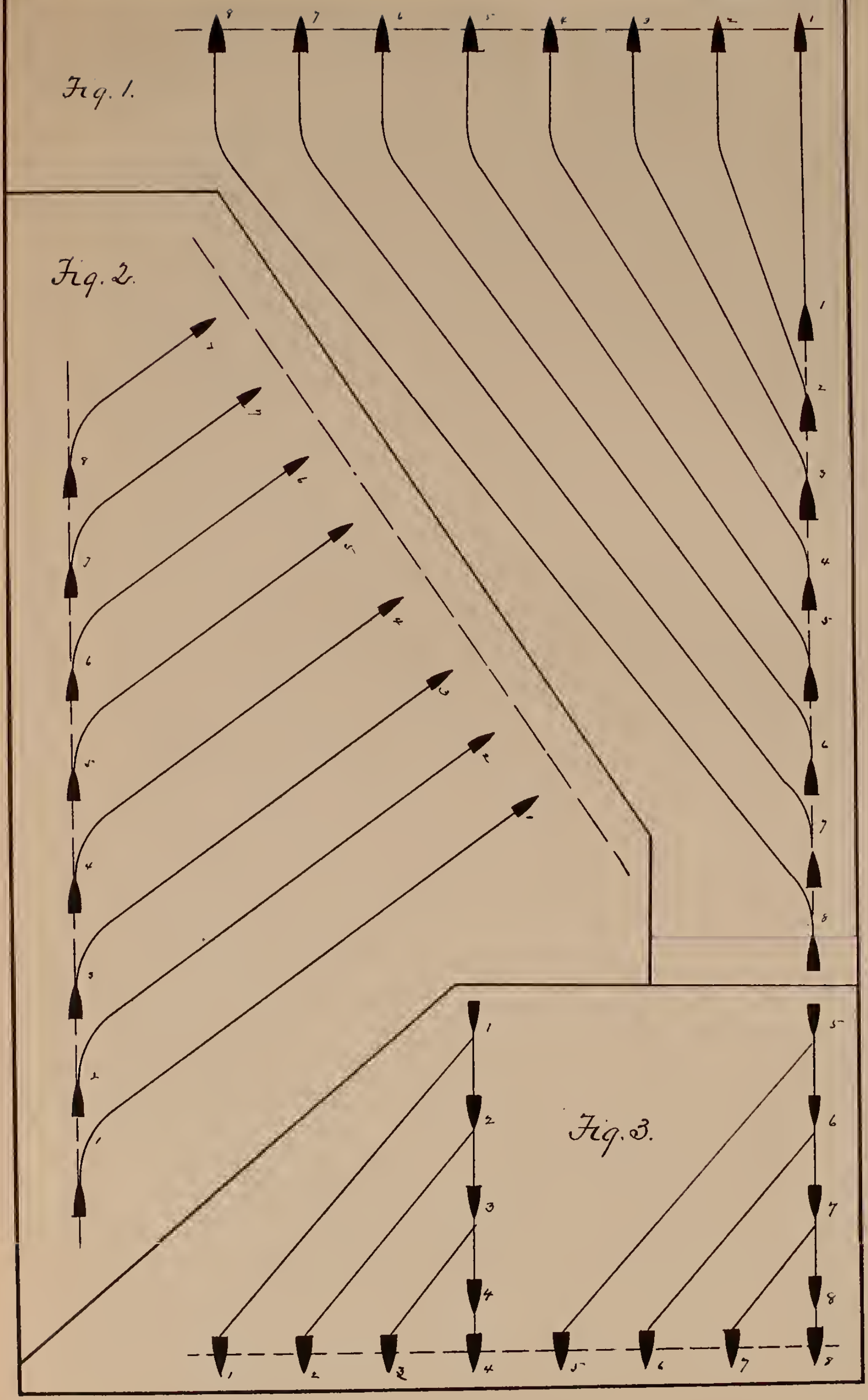
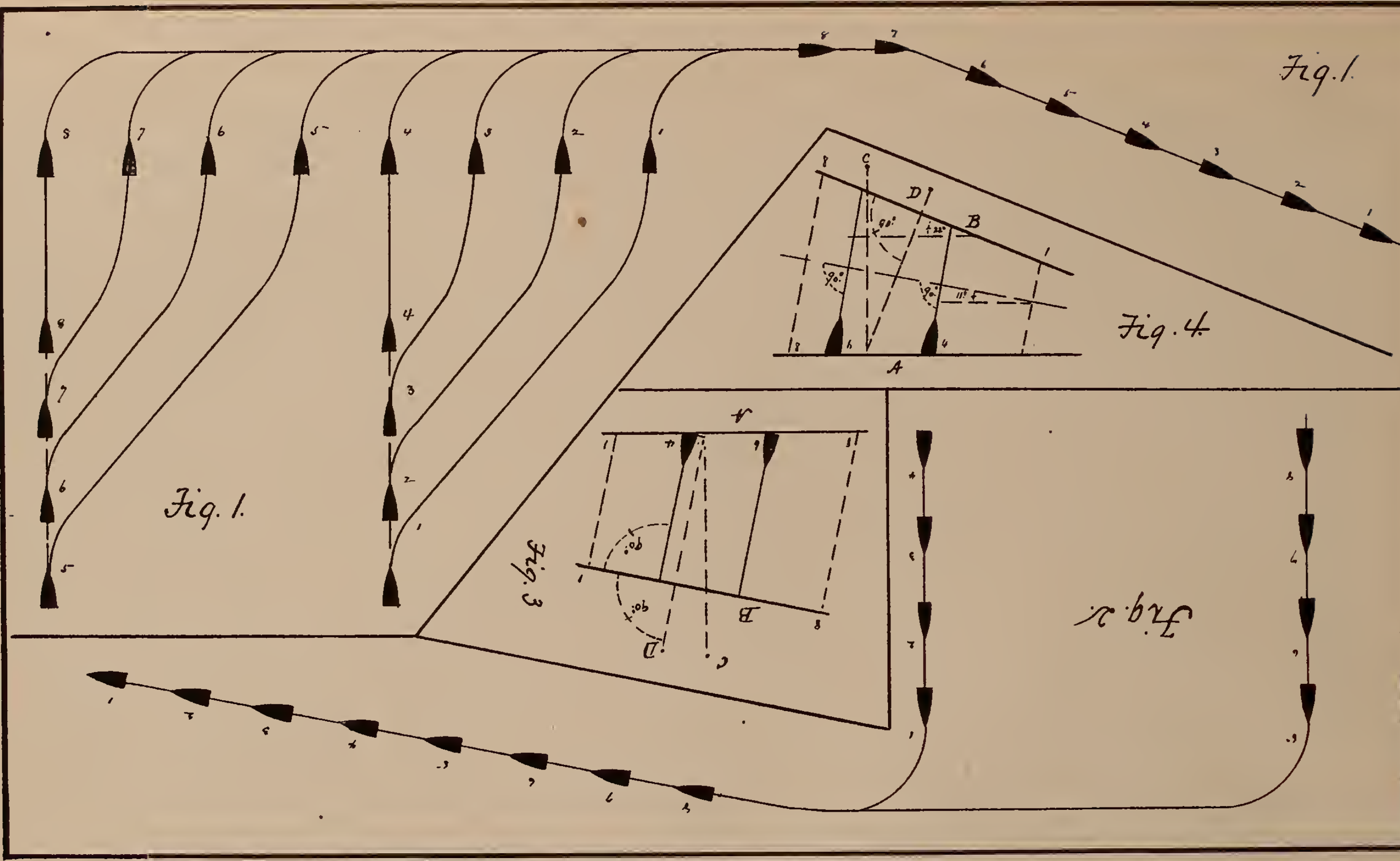


Fig. 1.
8 7 6 5 4 3 2 1
1 2 3 4 5 6 7 8
Fig. 2.
8 7 6 5 4 3 2 1
1 2 3 4 5 6 7 8
Fig. 3.
1 2 3 4 5 6 7 8
1 2 3 4 5 6 7 8

Plate XXII.



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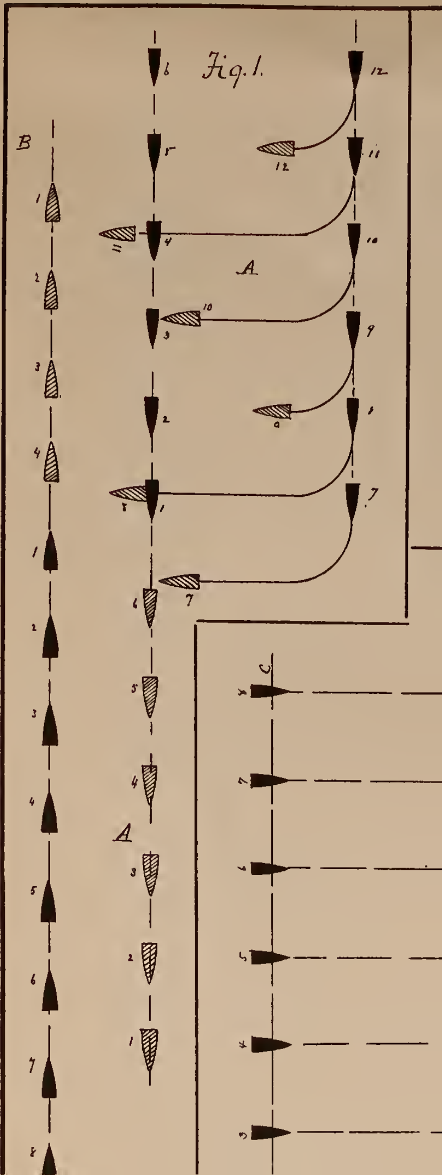


Plate. XXIV.

Fig. 1.

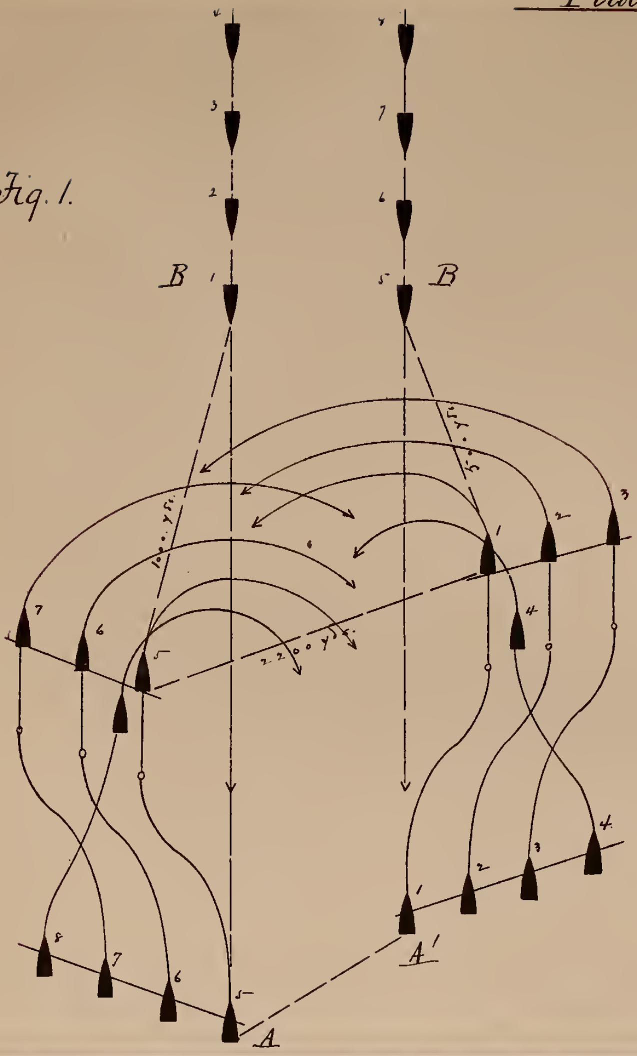


Fig. 2.

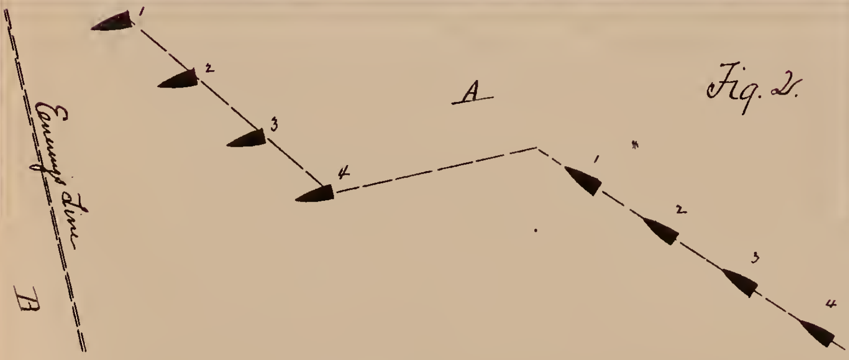


Plate XXV.

Fig. 1.

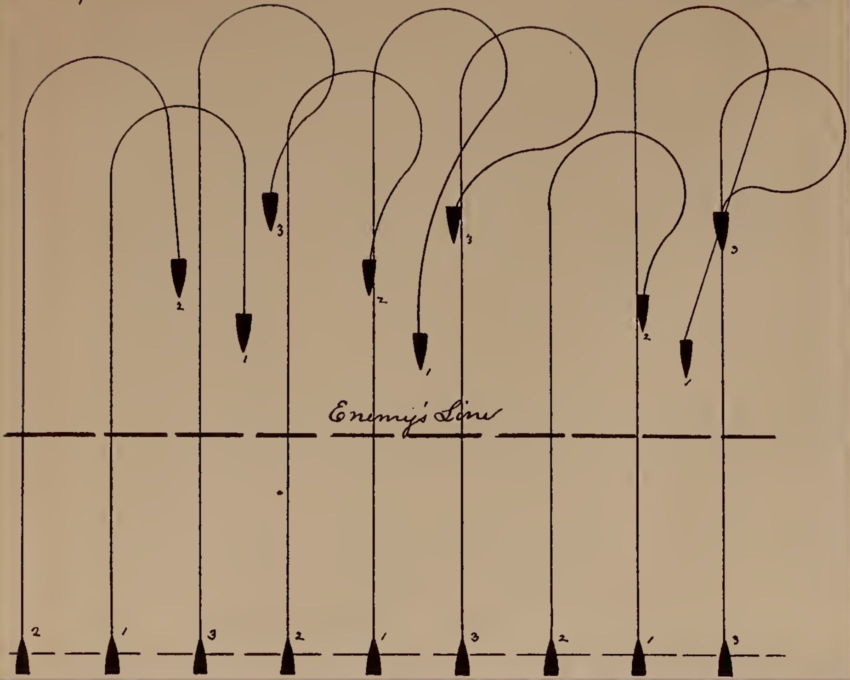
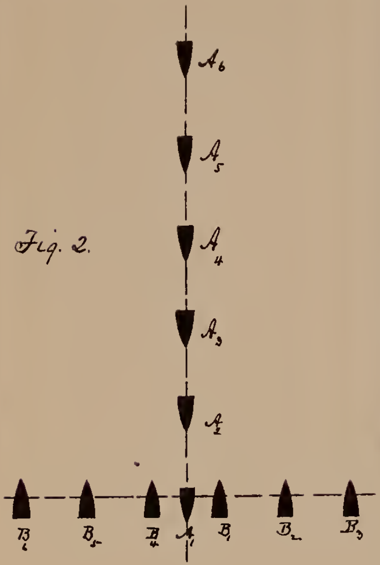


Fig. 2.



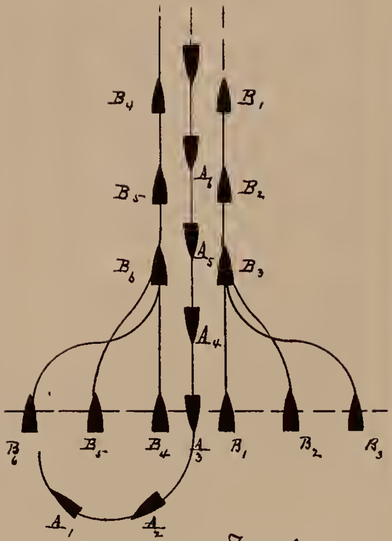


Fig. 3.

Plate XXVI.

Fig. 1.

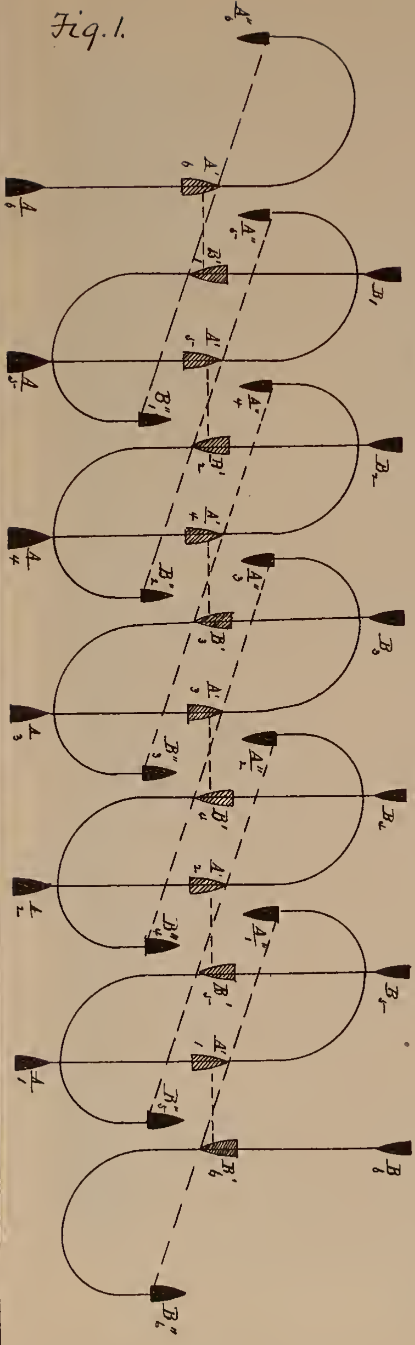


Fig. 2.